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6

A MANAGEMENT SERVICES TECHNICAL STUDY

PRACTICAL TECHNIQUES AND POLICIES FOR INVENTORY CONTROL

Staff Study Published by the
American Institute of Certified Public Accountants

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MANAGEMENT SERVICES
TECHNICAL
STUDY NO. 6

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Staff Study Published by the
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Management Services Technical Studies are staff publications of the American Institute of Certified Public Accountants. They are intended to be used as instructional matter. This study was prepared under the supervision of Henry De Vos, CPA, manager, management services. The members of the committee on manufacturing management assisted in an advisory capacity.

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Preface

Top management echelons in every sector of the business world concern themselves with almost every activity in the organizations for which they are responsible. The major and strategic marketing decisions, for example, are often felt to be too important to be left entirely to the marketing manager. Similarly, strategic changes in product lines, personnel policy, finance and new construction are reviewed at the board or executive committee level. Senior executives do realize, however, that they cannot immerse themselves in minute operating detail and that they must delegate the day-to-day operating decisions. But the determination of the company's basic policies and response to its environment is rightly the province of those who, as trustees for the company's shareholders, are responsible for its continued profitability.

One area in which management sometimes provides less long-term guidance and direction than is desirable is inventory control. Professional managers must be aware of the importance of inventory control, if only in its cash flow or fund use aspects. Too often, however, management seems to concern itself with what has already happened, i.e., asking why inventory levels have increased rather than providing guidelines by which inventory policies may be determined. Management's policy may then be characterized as reaction rather than planning. From such a position, it is impossible for management to lay down the decision rules on the basis of which inventory policy is to operate.

Inventory polices do have considerable strategic significance. The financing of increased stocks of parts or materials is a major use of funds and a basic factor in working capital management. Fund needs for inventory purposes competes with other uses of funds, and may be the deciding factor in decisions concerning long-term fund raising or the approval of new capital budget projects. A decision to adopt a "flat" rate of production where demand is seasonal and to absorb the difference between production and sales by means of increased inventory will have great significance for the company's personnel and recruitment policies and for its public relations with the local community. All these are matters of concern to the company's top planning and policy making group.

This is an area in which the CPA's advice may be invaluable. He can assist his corporate clients in two ways: by helping management to identify the costs on which inventory policy must be based (to be discussed further in this study), and, perhaps more important, by bringing a fresh, "outside" approach to problems in this area and identifying situations in which change is required but which have become accepted as part of the corporate environment. The most difficult problem may be the establishment of criteria upon which inventory policy should be judged. The CPA who has a sound basic understanding of the issues involved may render his clients valuable assistance in this area.

The purpose of this publication then is to highlight those issues and to show, through the case studies which follow, how the CPA can indeed help his clients.

This technical study has been prepared by Robert A. Farmer and Associates, Inc., and Henry De Vos, CPA.

*Practical Techniques and Policies for Inventory Control

THE NATURE OF INVENTORY

The basic justification for having inventories is to introduce a degree of flexibility into the manufacturing and merchandising operations. If it were not for inventories, each operation would then be perfectly synchronized with every other event: assembly parts, for instance, would be received at the plant at the very instant that they are required for assembly into the final product and that final product itself would be completed on the very day that it is to be shipped to the ultimate consumer. Clearly this is unworkable.

Inventories arise from a variety of circumstances and serve many specific functions. They provide the flexibility required for rational operational policies.

Transit Inventory

Wherever materials, work-in-process or finished goods have to be moved between locations, those materials or goods are not immediately available for further processing or sale. In effect, they are in temporary storage. The volume of the inventory resulting from this fact is a function of both the level of usage (or sales) and transit time. The time taken to move work-in-process items between operations in the machine shop is very short, perhaps a few minutes at the most. The transit inventory in this instance will probably be small, even at high levels of production. (In-process items may be seen around the machine shop in bins or on pallets for much longer periods but will, in such cases, serve quite a different purpose from that of transit inventory.) On the other hand, transportation of finished goods from the factory warehouse to distributor's depots will probably be considerably longer. If that is in fact the case, the transit inventory will be relatively large.

The creation of transit inventories is best demonstrated by a simple mathematical example. Assume that a distributor sells 150 units of a product per day, and that the transportation of this product from the factory to the distributor requires four days. Clearly it is not practicable for the distributor to wait until he has run out of stock before ordering further supplies of the product. His policy should be to so place his orders that some quantity of the product is always on its way to him so that during fairly stable conditions and level demand the amount in transit will be equal to the amount expected to be sold in four days. Thus, if an average of recorded sales in recent periods amounts to 150 units per day, the transit inventory should be:

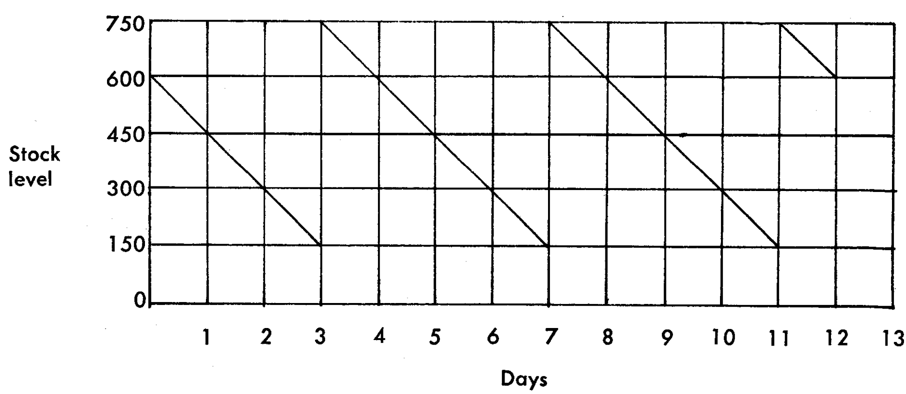
$$4 \times 150 = 600 \text{ units}$$

The distributor's daily stock record would appear as shown in Exhibit 1, below.

Two points of interest should be noted:

1. The distributor can not allow his inventory to reach zero. Orders must be so timed that new supplies will be received one day before the stock is depleted. This allows for a buffer or safety stock of 150 units. This will be discussed further in a later section.

Exhibit 1



2. The distributor's average inventory level should be equal to his safety stock plus half the order size:

$$150 + 600/2 = 450 \text{ units}$$

Up to this point it is assumed that the distributor believes that the demand for his product in the immediate future will be the same as in the previous period. The en route transit inventory therefore was the amount necessary to replenish inventory at a constant level. If however, there is reason to believe that the demand next period will be greater than the last period, orders equal to the transit time multiplied by the anticipated future demand rate with an additional quantity to increase the size of buffer stock must be placed. Transit inventories during periods where increased demand is experienced or expected, therefore, will be greater than those during periods of level demand.

In-Process Inventory

In most manufacturing industries, in-process inventory is relatively small, even where operations are on a large scale. A major automobile assembly plant which assembles perhaps 2,000 vehicles each day, for example, will have a limited in-process inventory because the timing and scheduling of deliveries and operations is tightly controlled. Each vehicle that leaves the final inspection line will have been constructed of components delivered to the plant only a few hours earlier, and the entire process is completed in less than a day.

A very different situation exists, however, in industries in which there is an element of "maturing" in the process. An extreme example is that of the wine industry, in which the volume of liquid undergoing fermentation or aging becomes the largest element out of the total investment in inventories. In such industries, financing in-process inventory often becomes the major use of funds provided by operations.

Organizational Inventory

Most production processes involve two or more distinct operations. If the in-plant inventory consisted only of units actually being manufactured at a certain moment (in-process inventory) and units being moved between operations (transit inventory), then it would be necessary to synchronize each operation exactly with the preceding and following operations. Where a single product is manufactured, this could be difficult. Where two or more products are made utilizing the same equipment, it could become quite impossible.

Suppose, for example, that a single product is being manufactured, and that the production of the product involves two distinct operations, "shaping" and "finishing." Each unit of product requires seven minutes "shaping" time and five minutes "finishing" time. It can immediately be seen that with only one shaping machine and one finishing machine it would be impossible to synchronize the two machines exactly. The finishing machine would be idle for two-sevenths of the working day. One solution would be to have seven shaping machines and five finishing machines thus:

	Shaping (Seven Machines)	Finishing (Five Machines)
Capacity:	1 unit every minute	1 unit every minute

Every five minutes the shaping group would produce five-sevenths of seven units (five units), equal to the capacity of the finishing group. It would then be a simple matter to synchronize the two. Such a solution, obviously, is only practicable if the scale of production is sufficiently large to warrant the purchase of that many machines. Suppose, however, that a new product is added, and that each new unit requires four minutes shaping time and two minutes finishing time, using the same machines. The position is now:

	Shaping (Seven Machines)	Finishing (Five Machines)
Original product capacity:	1 unit per minute	1 unit per minute
New product capacity:	$1\frac{3}{4}$ units per minute	$2\frac{1}{2}$ units per minute

Under these conditions it will be impossible to synchronize the operations when the new product is being produced unless some of the finishing machines are shut down for part of the day.

The easiest way to avoid this problem is to allow an inventory of shaped but unfinished parts to accumulate between the two processes.

At some point in the shift, this inventory will reach a peak. When that occurs, the shaping machines should be switched to another operation while the finishing machines continue operations until the temporary stockpile has been eliminated. Then the cycle will start over again. This temporary stockpile has simplified management's task by introducing a degree of independence between the two stages and reducing the coordination requirement. For this reason such inventory is called "organizational" inventory. It is often referred to as "decoupling" inventory.

Seasonal Inventory

In most instances the demand for a product is not evenly distributed over the year: frequently there are one or two seasonal peaks of demand with relatively slack seasons in between. Examples that are often used are manufacturers of Christmas decorations, sporting goods, outdoor leisure equipment, and certain gift items. A company producing these items could decide to match their output as closely as possible with the demand cycle; this would result in high levels of production during four or five months of the year in anticipation of the seasonal peak demand and a much lower level thereafter. Under such a policy there would be virtually no seasonal inventory. The acceptance of such a policy, however, would entail the hiring and training of new employees before every peak sales period, only to dismiss them in slack periods. The costs associated with such fluctuations may be very high. In that case, an alternative policy of maintaining a level rate of production throughout the year is often adopted. This allows for the accumulation of inventory during periods of slack demand and the reduction of inventory when demand reaches its peak.

The Sheldon Surfboard Company demonstrates this effect. Demand for the company's product, surfboards, is highly seasonal with a marked sales peak in June and July. The past five years has conformed approximately to the pattern shown in Exhibit 2, page 6.

Average monthly sales over the year are approximately 150 units, but the entire year's demand is concentrated within a seven-month period, March through September. If the company attempted to match production to the pattern of demand, it would be forced to close down completely during part of each year. However, Sheldon Surfboard sets its production at a level approximating the monthly mean demand of 150 units. Assuming that they begin their operating cycle in October and that sales during the peak season consumed all but the 20 units that remain in the factory warehouse at the end of September, Sheldon Surfboard would then produce in anticipation for next year's sales substantially as shown in Exhibit 3, page 7. That figure shows the relationship of production level, sales and finished-goods inventory in the factory warehouse. It can be observed that the finished-goods inventory has a marked seasonal peak immediately before the period of peak demand. This in turn is drawn down almost to zero by the end of the peak demand period in August and then commences to build up again in anticipation of the next seasonal demand period. In this way, production level is constant and the costs of seasonal hiring and firing are avoided. These benefits are, however, reduced by the cost of carrying or storing a seasonal inventory.

Batch Inventory

Under exceptional circumstances, the parts used in the fabrication of a product may be ordered or produced one at a time; this could be true for example in the construction of a major engineering project such as a special purpose furnace, a conveyor system for bulk-minerals handling, and so forth. But in normal circumstances and in most industries, all parts and materials used are bought or made in batches. The batch size may be determined by the practice of the trade, the minimum order size for which quantity discounts are given, or transport considerations; for many materials a carload is the minimum practicable quantity. The effect of these batch quantities is to produce a temporary stockpile of parts from which production requirements are drawn.

One of the basic materials used by the Sheldon Surfboard Company is glass fibre matting used as a reinforcing medium in the moulded

Exhibit 2

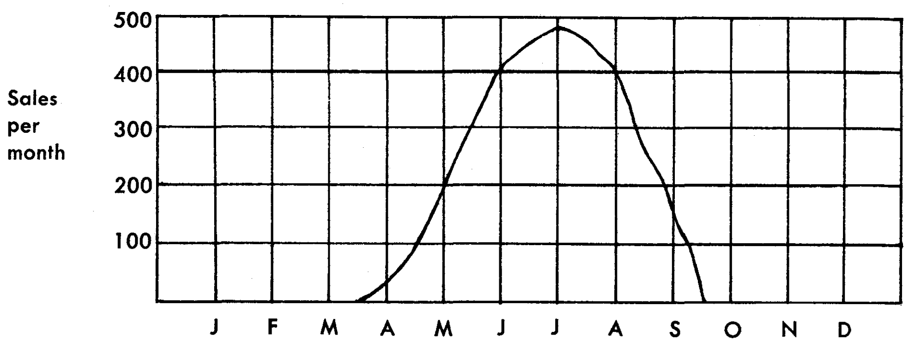
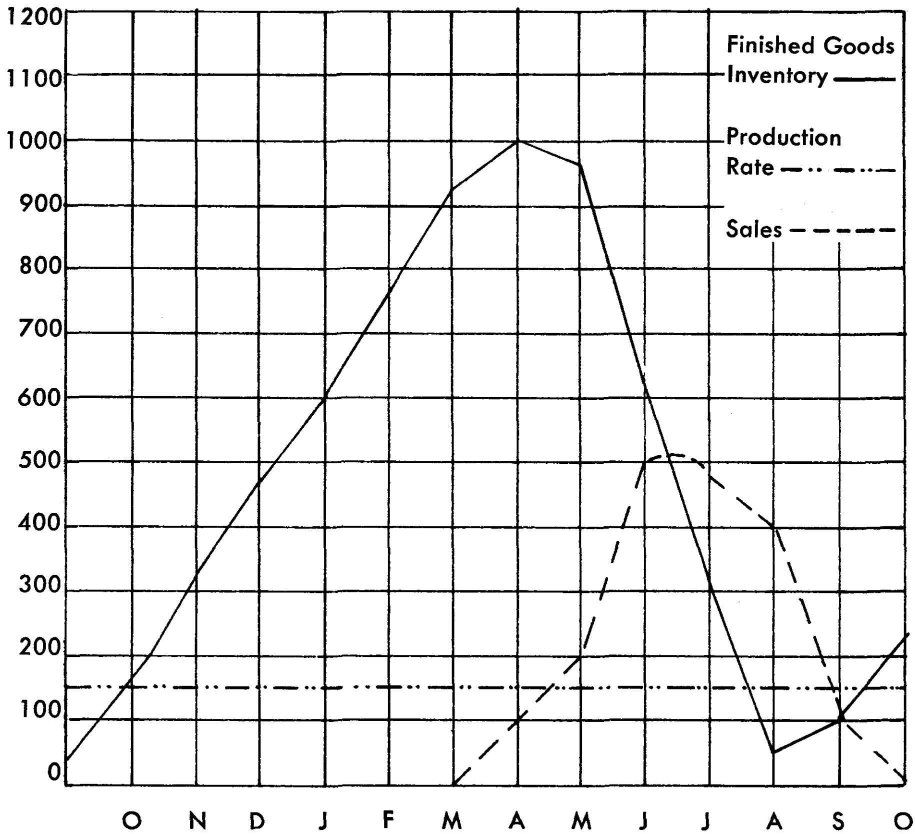


Exhibit 3



fiberglass surfboards. The producers of this material refuse to supply less than a carload lot at any one time. At a level of production rate of 150 boards per month, this represents a five-week supply of glass fibre matting. The inventory of this material over time will be as shown in Exhibit 4, page 8.

Once again it will be observed that the supply is never allowed to completely diminish. A reverse or "buffer" of one-week's supply is left on hand at all times. The average level of stock of this material will be:

$$\text{Buffer} + \frac{\text{Batch size}}{2}$$

$$= 1 + 5/2 = 3\tfrac{1}{2} \text{ weeks' supply.}$$

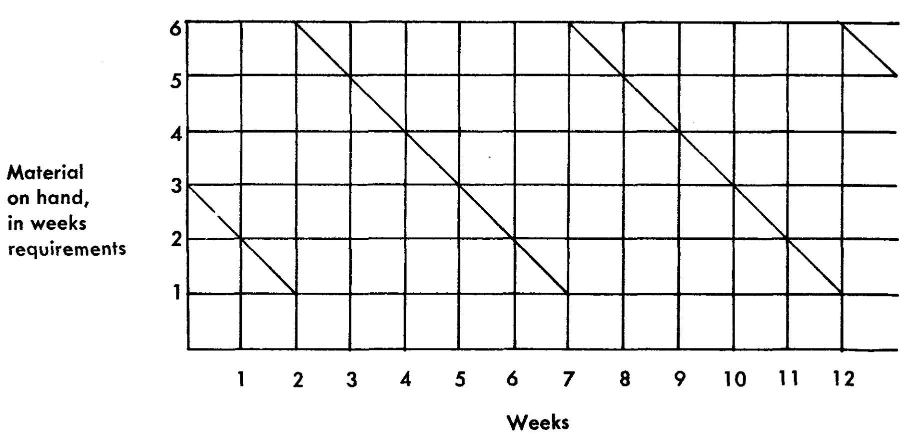
Buffer or Safety Stocks

Safety stock has already been encountered in this study. The distributor in the transit inventory example maintained a reserve of finished units in excess of expected demand. The surfboard manufacturer kept a reserve amounting to one week's supply of materials on hand. In these and all other cases, buffer stocks are a defense against the unpredictable. For example, sales demand may differ from what had been expected; delivery of the next batch of new material may be delayed by a strike at the supplier's plant or by the railroad. A typical protection against such contingencies is to keep a reserve on hand "just in case." This form of inventory, then, takes into consideration the element of uncertainty in most industrial activity.

An important point must be emphasized. The investment in buffer stocks really amounts to purchasing safety, but safety is relative. The decision to be faced is how much should be bought. The distributor in an earlier example expected retail demand to be 150 units of product per day, but by maintaining a buffer he acknowledged that he was not *certain*. It will be remembered that the distributor could not receive an additional supply in less than four days after placing his order. By maintaining a safety stock of 150 units, the distributor was in effect saying, "I expect demand to be 150 units a day, but I recognize that it could be as high as $150 + 150/4$ or 187.5 units, per day."

The distributor might have clarified his thoughts concerning this matter by assessing the probabilities for the various possible levels of

Exhibit 4



demand, thus: "I guess there is about one chance in twenty that demand will be as high as 188 units a day." If the distributor was asked what chance there was of demand equaling 200 units a day he might reply from experience, "Oh, around 1 in 100." In other words, he chose to invest in a safety stock which gave him protection against being out of stock at the 95 per cent level of confidence. Had the distributor chosen to cover the 1 in 100 situation, he would then gain the protection of a level of confidence equaling 99 per cent.

This "trade-off" of *degree* of protection against the *cost* of obtaining that protection is one of the basic policy decisions which management must make in the field of inventory control. However, many of these decisions are made unconsciously, or there is a failure to review such decisions once made. The decision must be made deliberately and reviewed in the light of experience. The CPA who does no more than make his client aware that such trade-off decisions exist will have rendered a valuable service.

DEVELOPING DECISION RULES

Relevant Costs in Inventory Control

The costs which bear directly upon the question of how much inventory to carry—and that must be considered in any answer to that question—fall into three categories: the costs of ordering or producing inventory, the costs of carrying inventory and the costs of being out of stock. The development of relevant cost figures is one of the most difficult aspects of inventory control. The costs required are not those normally found in financial statements, and will not be immediately available in organizations that have not previously employed formal inventory controls. The company setting up control procedures for the first time, or revising a long-obsolete system, is likely to rely heavily upon the advice of its accounting advisors, and it is essential that the CPA have a sound concept of what these relevant costs are.

The relevant costs are essentially incremental costs. They are not concerned with sunk costs, nor with those costs that remain to be liquidated in the future regardless of whether a particular inventory policy is adopted or not. A decision concerning whether a particular inventory policy should be employed will be based upon the additional costs of that policy, any costs which may be avoided by adopting that policy, and the loss faced if the policy fails to provide all inventory items when they are needed. The costs incremental to any one plan should be considered not in the abstract but in relation to the costs of alternative inventory policies. The inventory policy chosen should be that policy which, on the basis of cost data, minimizes total relevant costs.

Costs of Ordering a Set-up: Batch Costs

Two distinct elements may be identified in the cost of all items obtained for use in the company's operations. These elements are present whether a client chooses to buy the material from an outside vendor or whether he produces the material himself. On the one hand there are the costs which are usually referred to as "variable costs" but which are fixed in terms of units procured such as the material and direct labor content of items manufactured and the list price of the items purchased. The remaining costs are those which do not have a constant "per unit" relationship but are dependent upon the number of orders placed or on batches of units produced. It is the latter costs which must be considered in determining inventory policy.

These costs are normally referred to as "ordering" costs where items are externally procurred and as "set-up" costs where items are produced within the company. Both terms are oversimplifications. The costs in each case are basically similar but have a number of distinct elements as outlined below:

Externally Procured Items	Internally Manufactured Items
Cost of originating purchase order	Cost of originating work order
Clerical cost of receiving the material in the warehouse	Set-up cost
Material handling in warehouse	Jigs and dies
Shipping costs	Material handling in plant
Purchase discounts	'Learning' cost

The cost of the clerical work involved in the preparation of a purchase order is clearly an important factor in the total cost of placing an order. It is also an example of a cost figure which may not be readily available unless the company has instituted a clerical work study program. Some companies arrive at such a figure by dividing the total operating expenses of the purchasing department, including the salary of the manager, by the total number of orders placed. The average order cost thus obtained, however, is *not* an incremental cost. The cost required is the out-of-pocket cost of placing one additional order, and even a very approximate estimate of it is likely to be less misleading than an average cost which includes overhead expenses.

The cost of placing the order is not the only relevant cost. Other costs which will be incurred in connection with every order and will be largely independent of the size of the order include the clerical content of the receiving department's cost and, within broad limits, the cost of physically handling the material received. Transportation costs may be included in this category where, for example, it is necessary to send a vehicle to pick up the material whether the quantity involved is 500 or 5,000 units. Finally, it will be necessary to take into account quantity discounts which are not based on a constant "per order" cost element but rather act as an encouragement to reduce the number of orders placed. Quantity discounts are often an important influence in determining inventory levels.

The most obvious element in the "per-batch" cost of items produced within the company is the "set-up" cost: the labor involved in changing machine settings, tool bits, dies and fixtures when changing from a production run on one product to that on another. Here also, other costs are relevant: the clerical cost of making out a work order card, the cost of any extra jigs and fixtures required and the cost of material handling services required between operations which again, within broad limits, are independent of the batch size. Where the item under consideration is not produced by the company, an important element will be the "learning cost"; the cost of extra labor and spoilage which will be incurred until operators have become familiar with the process.

Inventory Carrying Costs

Certain costs are incurred when inventory is carried in stock. Two elements are of particular importance: the costs arising through "spoilage" of stocks which are held for any length of time and the opportunity cost or interest cost of the funds tied up. To these costs must be added a charge for the space occupied by the inventory, whether rented or owned, and the cost of insurance and taxes on that portion of the property.

"Spoilage" costs include physical deterioration of perishable stocks and losses through pilfering. A more important consideration in many cases, however, is the danger of obsolescence. Such a cost is particularly difficult to assess, but in circumstances where it is a conceivable threat, obsolescence is likely to be costly. The disposal of obsolete inventory items is often at prices well below cost, or, in extreme cases, it involves outright scrapping. Inventory decision rule policies which do not take into account the dangers of obsolescence, and its possible cost penalties, are far from optimal.

The derivation of the capital cost element in the cost of carrying inventory is controversial. Some companies use the rate of interest at which they can borrow funds as an inventory cost. Others use the "opportunity" cost or the interest which the funds tied up in inventory could earn if applied elsewhere in the company. The two methods give widely differing answers: the borrowing rate is unlikely to be more than 8 per cent whereas the opportunity rate may well be more than 20 per cent. One solution would be to use the borrowing rate when funds are plentiful and the opportunity-cost rate when funds are scarce and must be allocated among competing needs. Beranek,[1] in a recent book, offers a solution which seems more acceptable. He suggests the use of the borrowing rate when specific borrowing has been undertaken for the express purpose of financing inventory, with a repayment schedule such that the average amount outstanding is equal to average inventory; he recommends the opportunity cost rate in those cases where this requirement is not met. If, for simplicity, the CPA wishes to recommend to his client a single rate to be used in all circumstances, then that rate should be the opportunity cost rate.

The Cost of Being Out of Stock

Here, again, there is a need to develop a cost figure not normally produced by the existing accounting system. In order to do so, a considerable degree of judgment will have to be used. Stockouts may be experienced in raw materials and semi-finished inventories as well as in finished goods. In the former cases the relevant costs will include renumeration of operators temporarily idled by material shortages and the incremental expenses arising from any rescheduling of production required. If the stockout is in finished-goods inventory, the first consideration to be faced is whether or not orders are likely to be lost to competition. If this is the case, the relevant cost will be

[1] Beranek, *Working Capital Management*, Wadsworth, 1966.

the contribution to profit foregone on the items not sold. It may be argued that the real cost is considerably higher than this in that the company's relations with its customers may be damaged and future orders lost. If, however, management believes that the unfilled orders can be added to an order backlog and filled at a later date, the relevant costs will be those of the extra clerical work, telephone calls, expediting and, possibly, additional transportation expense.

How Much to Order or Produce

When the relative costs have been determined, they must then be plotted to determine how total costs will vary under different inventory ordering policies. A formula can be introduced by which optimum order or production batch quantities may be determined.

The Rawcliffe Company produces automobile accessories of various kinds. A number of these accessories employ 3/16″ machine screws, and the company's usage experience is 2,500 units per week or 125,000 per year. The cost of the screws, purchased in quantities of at least 5,000 is \$4 per 1,000. The cost of placing an order for the screws is \$5, irrespective of the quantity ordered. The risk of obsolescence is negligible, and the cost of storage has been estimated at \$1 per 1,000 per year. The company's rate of return on capital employed is 10 per cent per year. In the first instance it is assumed that stockouts are not considered possible as demand can be forecasted with certainty. The total costs of alternative inventory policies can then be calculated as shown in Exhibit 5, page 14.

Clearly the first policy, ordering twice a year, involves lower total costs than ordering a small quantity every two working weeks. The optimum may or may not be somewhere between the two. Since it would be highly inconvenient to have to perform such a calculation for every possible ordering policy, the following formula is used to indicate the optimum order quantity.[2]

$$Q_0 = \sqrt{\frac{2C_0R}{I}}$$

where Q_0 = Optimum order quantity
C_0 = Cost of placing an order
R = Annual usage
I = Inventory carrying cost per unit per year

[2] The formula assumes a relatively constant usage throughout the year.

This formula can be applied to the Rawcliffe Company's problem as follows:

$$Q_0 = \sqrt{\frac{2 \times 5 \times 125{,}000}{.0014}} = 29{,}880 \text{ units.}$$

In other words, the company's optimum order policy is to place an order for a batch of 30,000 units when new supplies are required—approximately every 12 weeks if usage is spread evenly over the year. If total costs under this policy are calculated by the procedure used in the table above, they will amount to $36 per year.

The method used to calculate the optimum batch size (length of production run) where the items are produced by the company rather than purchased is essentially the same but requires a modification of the formula to reflect the difference in average inventory. When components are purchased from outside vendors, the components are normally delivered in a single batch (equal to the order quantity, Q_0) and this stock is then gradually depleted until another batch is received. Average inventory therefore amounts to one-half of the quantity ordered. When the component is produced, the plant stock depends upon both the rate at which the components are being pro-

Exhibit 5

Policy:	Order Twice a Year	Order Every Second Week
Annual usage	125,000	125,000
No. of orders*	2	25
Order batch size	62,500	5,000
Average inventory Q/2	31,250	2,500
Carrying costs:		
Storage cost	$31.25	$2.50
Capital cost	12.50	1.00
	$43.75	$3.50
Cost of placing orders	10.00	125.00
Total cost:	$53.75	$128.50

* For the purpose of this table, a 50-week year is assumed. This assumption will be maintained in the study.

duced and the rate at which they are used in the final product. Average inventory in these circumstances will be:

$$Q/2 \times \left(1 - \frac{R}{P}\right)$$

where R is the annual usage rate as before and P is the annual production rate if the item were in continuous production. The optimum batch size formula then becomes:[3]

$$Q_P = \sqrt{\frac{2C\ R}{I\ \left(1 - \frac{R}{P}\right)}}$$

C in this formula is the cost of setting up the machinery to produce a particular component.

Assume, for example, the Rawcliffe Company has sufficient screw-cutting machine capacity to permit it to produce its requirements of the 3/16″ machine screws instead of buying them from outside suppliers, that the set-up cost is $5 and the rate at which the screws can be produced is 375,000 per year. Using the above formula it is noted that, by shifting from a policy of purchasing to one of internal pro-

$$Q_P = \sqrt{\frac{2 \times 5 \times 125{,}000}{.0014\ \left(1 - \frac{125{,}000}{375{,}000}\right)}}$$

$$= 36{,}660$$

duction of the screws, the optimum batch size increases from 30,000 to 37,000. This is not surprising because requirements are now produced over a period of time rather than being received in a few large consignments. This results in a lower average inventory which in turn lowers the carrying cost. Further, the break-even point between the cost of ordering versus the set-up and carrying cost has moved to a higher figure.

It is now possible to calculate the optimum batch sizes for purchased and internally produced parts. In many cases, a further saving in clerical effort is possible. It will be observed that some of the cost figures

[3] See footnote 2, page 13.

used are likely to be common to every calculation, particularly the capital cost element in inventory carrying costs and the cost of placing an order. If a slight oversimplification is accepted and the carrying cost is treated as a percentage of the purchase price, a table of economic order quantities can be constructed using the formula on page 13. The batch size for subsequent items may then be read directly from the table without further calculation. A further possibility is to construct a nomograph from which the batch sizes may be read. Discussion of the techniques used to construct such tables and nomographs can be found in a number of standard texts on production and inventory control. Reference should be made to the bibliography at the end of this study.

When to Order

The question of when additional material or components should be ordered, unfortunately, cannot be answered simply by "when necessary." Two complicating factors exist. First, when many hundreds or thousands of items are in inventory, no single person can be expected to remain aware of the stock levels of all items. Therefore, some kind of system which will signal to management the fact that stocks of a particular item are dangerously low must be devised. If perpetual balances are not monitored daily, "review cycle" lead time will be required. In addition, few items or materials are available immediately; time must be allowed for processing an order, for transportation from manufacturer to user, and perhaps for the fabrication of custom items. There will be a time-lag, which is called "lead time," between ordering and receiving that item. The order must therefore be placed some time before a stockout. An adequate reserve must be left on hand to meet sales demands during the lead time. A further complicating factor is that demand during the lead time will rarely be known with certainty and will usually take the form of a probability distribution. Three of the essential factors in the determination of inventory policy, therefore, will be management's estimate of lead time, of the usage or demand likely to be experienced during this lead time, and the decision as to the degree of protection required against stockouts—i.e., whether a limited possibility of a stockout is acceptable or whether the company will try to achieve 100 per cent coverage of any possible demand.

The most frequently used inventory control mechanism is that known as the "fixed order quantity system." Under this system a predetermined quantity of stock, usually calculated on the basis of the formulae introduced in the preceding section, is ordered whenever inventory on hand falls to a particular level. The stock level at which the "reorder" signal is generated is the "buffer stock."

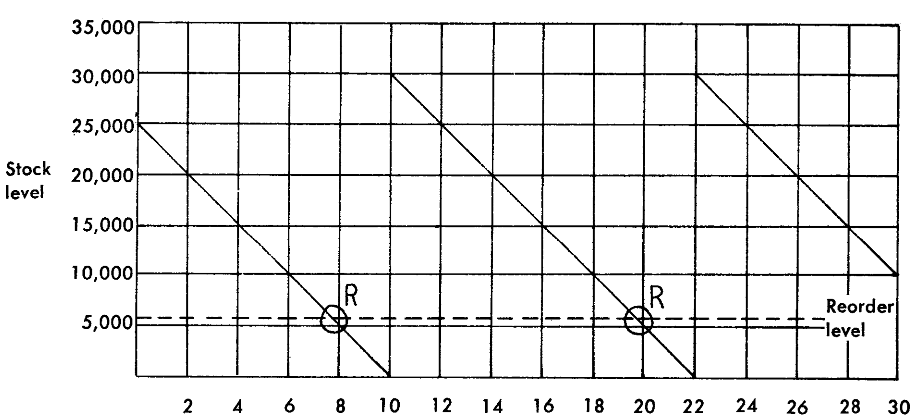
If demand during the lead-time period could be forecast with complete accuracy, it would be a simple task to calculate the necessary buffer-stock level. Assume for example that the usage of the 3/16″ screws in the examples given earlier is completely predictable at 2,500 per week and that the screws were purchased from an outside vendor. The time lag between ordering more screws and receiving them into store was determined to be two weeks. The buffer stock would amount to 5,000 units as follows:

$$\begin{aligned}\text{Buffer stock} &= \text{Lead time in periods} \times \text{usage per period}\\ &= 2 \times 2{,}500\\ &= 5{,}000\end{aligned}$$

Therefore, a new order for 30,000 units should be placed whenever the inventory stock of screws falls to 5,000. The inventory of this item will then follow the pattern shown in Exhibit 6, below, with new orders being placed at point R in weeks 8 and 20.

Where usage during the lead time is not known with certainty, calculation of a buffer stock level is considerably more difficult. Suppose that Rawcliffe Company's schedule for the products in which these screws are used is tied closely to new-car sales month by month and is, therefore, highly variable and difficult to forecast. Management might state its position thus: "We expect to use around 2,500 of

Exhibit 6



these screws per week. There is a one in ten chance, though, that usage may be 3,500 and a one in 20 chance that it may be as high as 4,500."

The essential point to be made here is that the buffer stock will be decided by a trade-off between protection and cost. If the possibility of a stockout is completely unacceptable, then management will wish to decide upon a rate of usage which in their opinion cannot possibly be exceeded and will use that rate as the basis for a buffer stock. Such a policy will give complete protection, but at a high cost in inventory carrying charges. More usually, management will decide that *some* chance of running out of stock is acceptable. If the acceptable chance is one in 20, then the buffer stock will be lead time in periods multiplied by the estimated usage per period ($2 \times 4{,}500$ or 9,000).

In statistical terms it could be said that a buffer stock of 9,000 will provide protection at the 95 per cent confidence level, which means simply that the odds are 19 in 20 in favor of having enough stock to carry the company safely through the order lead time. A similar calculation will show that at the 90 per cent confidence level a buffer stock of 7,000 would be indicated.

If the "buffer" has been set at a level which gives protection against the one in ten chance of demand amounting to 3,500 units per week during the lead time, then, whenever sales are close to the expected (average) figure of 2,500, part of the buffer will still be on hand when the stock replenishment is received. This reserve of 2,000 (one in ten usage (3,500) times lead time (2) = 7,000 units; normal usage (2,500) times lead time (2) = 5,000 units; safety stock = 2,000 units) units is called the "safety stock" element of the buffer. The average inventory will then be:

$$Q/2 + \text{safety stock} = \frac{30{,}000}{2} + 2{,}000 = 17{,}000$$

In circumstances where the possibility of running out of stock is accepted, even at the one in 20 or one in 100 level, the quantity formula should theoretically be modified to take into consideration the cost of stockouts. This matter is treated in full in most textbooks on inventory control. The bibliography lists some of the texts that cover this matter. The formula used in such instances is:

$$Q_0 = \frac{2C_0R}{i} \times \frac{i + C_s}{C_s}$$

In the above formula, C_s is the cost of one unit being out of stock for one period of time. The net effect of applying this formula is an increase in the order quantity and an increase in average inventory—resulting in an increase of inventory carrying cost. In most cases, however, the difference is small. A major change in the indicated optimum order size will arise only when the inventory carrying cost is very high in relation to the cost of stockouts. In a majority of cases, the formula on page 13 would be an acceptable approximation.

When both the order quantity and the reorder level (buffer stock) have been calculated, a mechanism must be set up which will indicate when the stock of a particular item has fallen to the reorder point. This may be accomplished by a physical system such as the two-bin method, described in detail in the National Ventifan case later in this study. Such a procedure is often used for low-cost items where stock records can be eliminated. In a highly mechanized control system where stock records are kept on computer tapes or discs files, it is a simple matter to program the computer to print out "reorder" signals as the predetermined level is reached. In most cases, however, stock records are kept in a conventional card file system. In these situations the record cards provide the reorder signal. Each card carries a notation of the reorder level for that item. Whenever a stock clerk enters a withdrawal on the card, he compares the new balance with this predetermined level and institutes a reorder procedure if the balance is equal to or less than the reorder point.

Two important points must be made. The first is that the stock-control staff must be convinced of the need for accurate record keeping and scrupulous observance of the reorder procedure. Every issue of material from stock must immediately be recorded on the stock cards. Periodic spot checks by management, in which a physical count of a few items is taken to check the accuracy of the record cards, is one way of imposing this discipline; but a better solution is to educate stores and stock-keeping personnel to understand the importance of accurate records and their role in the overall production-control system. Second, order quantities and reorder levels *cannot* be set once and then forgotten. Constant review is required, and whenever a basic change in demand levels becomes apparent, (as opposed to a short-term fluctuation), the quantities must be recalculated and new figures must be entered in the record cards. The problems of recognizing demand trends, forecasting future demand, and making adjustments on a "smooth" basis will be considered in detail in Technical Study Number 7.

SOME ADDITIONAL TECHNIQUES

A-B-C Analysis

The determination of inventory policy requires that management make a series of trade-offs between conflicting sets of costs—i.e., between the costs of ordering and the costs of holding inventory, between the costs of holding safety stocks and the possible cost of running out of stock. A further trade-off which must be made is that between the benefits obtainable from an inventory policy and the costs of administering the policy in terms of management time. A "near-optimum" policy, which requires less manpower to both set up and maintain, is often more feasible than a fully optimum one.

The complete inventory of materials, parts, spares and maintenance supplies for a medium-sized manufacturing company is likely to account for many thousand separate items. Some of these will consist of low value items. Others will be used infrequently so that the inventory turns over very slowly. A method of classification has been developed using both unit value and stock turnover. This method is known as "usage value analysis." The unit value of each item is multiplied by its usage over the past year or, preferably, its average usage over the past three years; all inventory items are then grouped into classes according to these "usage values." Almost invariably, a small group of items, between 5 and 10 per cent of the total items in inventory, will be found to contribute 75 to 80 per cent of the total usage value. Controlling these few items will generally account for 75 per cent or more of the total dollar value of inventory used. The saving in managerial and clerical labor will also be very large.

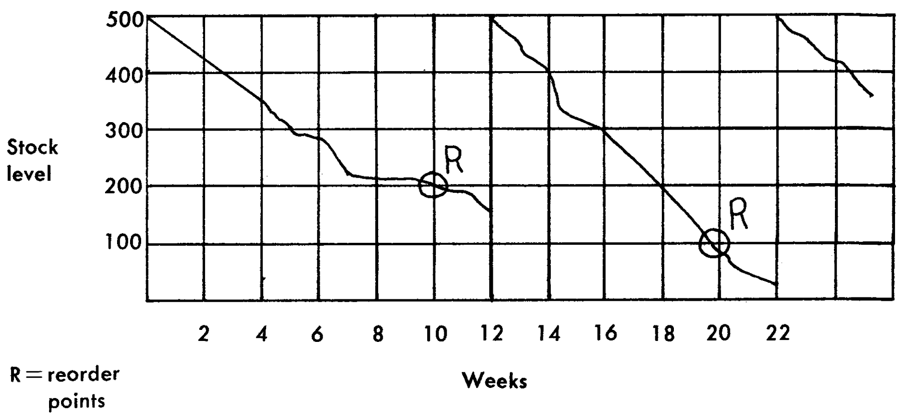
Such systems are commonly known as A-B-C classification systems because those that employ this method frequently use three classification groups. Type A items, the top 5 or 10 per cent by dollar value of annual usage, are closely controlled, perhaps to the extent of re-evaluating their batch sizes and reorder levels every three months. The next 25 to 50 per cent of the items, called type B, are subject to less strict control: full inventory records are kept for these items but quantities and reorder levels are reviewed less frequently. The remaining items, type C, are regulated even less closely; perhaps, a "two-bin" physical reorder control system might be used and stock cards eliminated entirely. For the smaller company, a two-classification system might prove more workable—an A classification indicating items which are closely controlled and a B classification embracing all other items.

The Fixed Order Cycle System

This procedure is an alternative solution to the problem of when to order. The methods so far described involve a batch size which is fixed between reviews and a reorder cycle which is flexible, depending upon usage rates. The "fixed order cycle system" is the antithesis of this, involving reordering at a fixed time but varying the reorder quantity to bring inventory up to a predetermined maximum. If, for instance, a particular item is reordered on a fixed ten-week cycle to a maximum level of 500, the stock cycle for this item, assuming usage of between 25 and 50 items per week, and a lead time of two weeks, will be approximately as indicated in Exhibit 7, below.

It is apparent from the above diagram that the quantity ordered in week 20 will be considerably larger than that ordered in week ten because the rate of demand in the intervening period has increased. The quantity ordered on each occasion will be an amount equal to the normal usage during the two-week lead time plus whatever amount is necessary to restore the inventory to its predetermined level of 500 units. This quantity of 500 units is, of course, management's estimate

Exhibit 7



of the "normal" usage during the ten-week cycle plus an element of safety stock.

The fixed order cycle system is sometimes advocated as a way of reducing the cost of constantly reviewing inventory levels. Under the fixed order quantity rule, it is argued, inventory levels must be kept under constant and close supervision to ensure that new orders are placed whenever any item is depleted to reorder level. The fixed order cycle system therefore reduces the degree of supervision required and the possibility of error by substituting a rigid pattern of reorder or predetermined dates.

The development of the A-B-C classification system and the two-bin method have considerably reduced the amount of close supervision required under the fixed order quantity system, however, and the fixed cycle system no longer has any significant advantage in this area. The one situation in which the fixed order cycle may be preferable is where a large number of different items are purchased from a single vendor. In that case, considerable economies can be achieved by ordering all such items on a single order form. These savings are only achieved by scheduling all reorders for items purchased from the same vendor to fall on the same day.

The fixed cycle system is, however, particularly dependent upon accurate and up-to-date information feedback on usage and the development of new trends in usage patterns. If the usage of any one item suddenly increases under the fixed order quantity system, that item will simply be reordered more frequently because stock will fall to the reorder point more rapidly. The only danger of a stockout will be during the lead time. Under the fixed cycle system, however, a large increase in usage could result in a stockout well before the reorder time is reached. Buffer stocks under the latter system must therefore provide protection throughout the whole cycle, not just during the lead time, and the system must be considered more vulnerable. It should be recommended with great reservation and only after very thorough study of demand patterns.

Electronic Data Processing

Inventory control is an obvious possible application of electronic data processing equipment, and most companies which have introduced computers into their operations have adopted some measure of automation in their stock control procedures. The degree of sophistication, however, varies considerably. Three distinct stages may be identified: mechanizing procedures previously performed manually, performing additional operations which could not be performed manually, and, finally, using the computer as an adjunct to decision-making.

The first stage is a fairly predictable one. Inventory control systems of the kinds already described, using formulas to determine order sizes and establishing reorder points for all items, are largely automatic in nature and call for relatively little discretion on the part of the clerk. Such automatic actions may easily be performed by a computer. The card files, by means of which inventory records have been kept, will be replaced by record files maintained on magnetic tape or storage discs. Every withdrawal or receipt of stock will generate not an entry on the record card but a punched card that is then fed into the computer on a daily updating run. The program will include an automatic comparison of the new balance with a stored reorder level after every transaction, and a reorder list of all items which have fallen to the reorder point will be printed-out after updating the run.

This phase should not be taken too literally. One of the major advantages of installing a computer system is that it forces management to review its established practices. Procedures may have to be streamlined, redundancies should be eliminated, the information-flow improved, and a greater degree of coordination between different areas and functions should be achieved. But the basic decision rules as to when to order and how much to order remain unchanged at this time.

It must be stressed, however, that in many cases the stores clerks will be doing more than performing a routine function. One of the cases in this study, that of Laminated Plastics Company, describes a situation in which the stores control staff performed a sophisticated reordering procedure designed to reduce ordering costs where a number of items were purchased from a common supplier. In that case, the clerks employed considerable discretion in deciding how to schedule orders for internally produced parts. Most of these functions *could* be transferred to the computer through the use of multiple reorder points. The important point is that the system study which is an indispensable part of the computer feasibility survey must identify all the functions being performed.

The second stage may be described as building-in a degree of sophistication. At this stage the company begins to do things which were simply not practical under a manual system. A good example of this is the calculation of order quantities. In a manual system, this can be done only at infrequent intervals. Where the A-B-C classification system is used, the order quantities for class A items will be reviewed more frequently, perhaps once a month. The computer's speed in performing routine calculations makes it quite possible to revise the order quantity of every item after every transaction if management believes such a policy would be desirable. Similarly, programs may readily be written to update forecasts of future usage on the basis of moving averages or smoothed trends of recent actual demand and the results used to revise buffer-stock levels automatically at regular intervals. Any desired degree of "damping" may be built-in to avoid undue variations in the parameters and to differentiate between long-term trends and short-term fluctuations. Forecasting and trend-sensing problems of this nature will be considered in Management Services Technical Study Number 7 (to be published).

The final stage is that of simulation. In this phase the computer is used not only to operate inventory decision rules but to evaluate them. Programs can be written which reproduce as nearly as possible the functions of the production-inventory system using existing decision rules. Data is then fed into the model to simulate demand for an item. For example, actual figures from some past period or a Monte-Carlo type random-number generator may be used. The performance of the system is then observed, the decision rules are modified where it appears appropriate and the procedure is repeated. The use of simulation may avoid many costly mistakes. Simulation of inventory control problems is still relatively rare. Interest in the whole subject of simulation is increasing rapidly. There can be little doubt that this technique will play an increasingly important part in inventory control during the next decade.

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In addition to the above publications, the reader may also wish to avail himself of *An Auditor's Approach to Statistical Sampling,* a series published by the American Institute of Certified Public Accountants.

The Topworth Toy Company

In October 1967, Richard Topley, founder and chief executive of The Topworth Toy Company, met with his CPA, John Lewis, to discuss his company's performance during the year ended August 31, 1967. The recorded profit for the year was disappointing and had been something of a shock to Topley. The situation may be summarized by his closing remarks to Mr. Lewis:

"John, this is the best year we have ever had in terms of sales. Our sales revenue is an all-time record at $450,000. And yet we only made $20,000 in profit. There is something wrong here. I think we run a fairly low cost operation—we don't buy a single piece of equipment without a very good reason for doing so, and we have developed skills in keeping our old machinery going that practically amounts to genius. I pay myself a salary much lower than I could get by working for somebody else. I'm sure there should be more of a profit in the operation than a miserable $20,000. One of our problems, of course, is that this business is so seasonal that for half the year we are lucky to have any work on hand at all. Perhaps we should try to find a completely different product.

"I know I procrastinated on your recommendations in the past, but before we get deeply involved in another year, do you think you can perform an investigation for us to determine what's going wrong?"

Mr. Lewis promised to do some further analysis of the operating figures and to try to find the reason for the company's poor profit performance. He suggested another meeting in two weeks.

Background

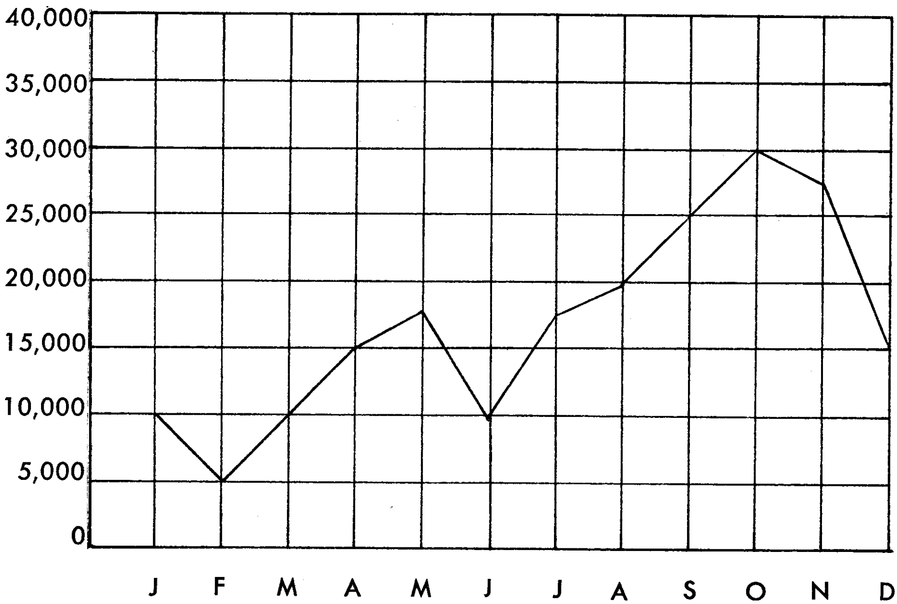
The Topworth Toy Company was founded in 1955 by Mr. Topley. The initial financing had been provided through his personal savings. The venture proved successful and in 1961 further funds were provided by a $250,000 debenture placed privately with a number of local investors. Mr. Topley continued to own 100 per cent of the equity interest in the company.

Topworth's products were a range of "soft toys" selling at prices between $2 and $3.50 each. These toys were stuffed, washable figures of various animals. The outer "skins" of the animals were cut from acrylic-pile materials or poly-vinyl chloride sheets. Stuffing materials were either latex or plastic foam. The major operations consisted of stamping out the basic shapes, seam sewing or heat welding, stuffing, finishing and packaging. The direct labor content in this work was high, only the stamping-out operation being fully mechanized.

Demand for Topworth Company's products was highly seasonal, with a peak demand occurring in October and November when retail stores made their purchases for the Christmas season. The pattern of sales during 1966 is indicated in the graph shown as Exhibit 1, page 28. Sales were made directly to retail outlets or to the central purchasing organizations of retail chains. The company employed two fulltime salesmen. Mr. Topley also concerned himself directly in the sales activity, and the company's longer-established customers expected to deal with Topley in person rather than with a sales representative.

During most of the year, the Topworth products were produced only to order. In the ten-week period, from early August to mid-October, however, Topley tried to anticipate which lines would have the heaviest demand and to produce some inventory ahead of orders. On the whole, however, production levels followed demand very closely and had the same seasonal peak. The monthly production figures ranged from a low of 7,000 to a high of 30,000. One result of this fluctuation was a considerable variation in the size of the direct production work force. A regular full-time plant production head count of 15 to 19 men was maintained. This was supplemented during the period of peak demand by temporary and part-time labor. Therefore, as many as 80 production workers might be employed during the peak months of

Exhibit 1



September and October. The company went to two shifts during that peak period and operated one shift during the remainder of the year.

The accounting functions performed by the Topworth staff consisted of little more than invoicing, maintaining customers' and suppliers' accounts, and preparing the company's payroll. No formal cost accounting system was employed although it had been recommended on several occasions. Topley and the production superintendent priced the products on the basis of their experience with the company's operations.

Lewis' Study

After his meeting with Topley, Lewis spent considerable time thinking about his client's operations. He was convinced that Topley was right in attributing his poor profit performance to the seasonal nature of the business, but the lack of real cost information made it difficult to see where the problem was. He decided that Topworth's products were so similar in nature and had such a small spread in selling price that it would be reasonable to think in terms of an "average" unit of product and to spread the total labor and materials costs over total production on that basis. This calculation produced the following figures:

Total production (year ending August 31, 1967) in units	180,000
Total direct labor (year ending August 31, 1967)	$153,000
Average direct labor cost per unit	$0.85
Total direct materials (year ending August 31, 1967)	$ 81,000

Lewis was not surprised to find that the direct labor was a relatively large item in the cost of products of this nature. He wondered, however, about the real labor cost. He was certain that Topworth Company's production policy was uneconomical and decided that the most significant factors would be the cost of training a new labor force every year, the cost penalty inherent in the relative inefficiency of temporary workers, and the extra costs associated with the second shift during the peak production period. It seemed, therefore, that the possibility of introducing a new policy which would spread production evenly over the year and reduce the high labor turnover was worth further study. Such a policy would mean, of course, that stocks of finished items would be built up during the periods of low sales volume and then run down during the period of pre-Christmas sales demand.

The choice would be between the present system with its inefficient use of labor and a system which would achieve labor efficiency at the expense of carrying an inventory of finished goods. The costs of holding such an inventory would be the deciding factor. Lewis decided that this was the avenue he should propose to the Topworth executives and he arranged to talk to Topley and his production superintendent, Mr. Castaldi, on the following afternoon.

The Second Meeting

The next day, Lewis met with Topley and Mr. Castaldi in Topley's office. The following is excerpted from their conversation.

Mr. Lewis: I am inclined to believe that a major part of your present difficulty arises from your high direct labor costs. The trouble is not so much that demand for your product is seasonal but that you have a seasonal pattern of production. It seems to me that before you start talking about looking for a different product you should examine the possibility of smoothing out production by spreading it over the year and building up stocks.

Mr. Topley: Well, that is a possibility, and one that should be considered, but I am not convinced that that is our answer. I hope you can give me some figures. It seems to me that we would tie up a lot of cash with that sort of policy.

Mr. Lewis: I only have some rough figures. This again points out the importance of installing a cost accounting system as I have recommended in the past. However, I hope to have some better figures after I have cleared a few points with you. I'd like to start by talking about the temporary labor you hire every year. Can you give me any idea how efficient these people are compared with your full-time people and how long it takes to get them up to their full productivity?

Mr. Castaldi: It's hard to give you that in figures—we don't have any time standards here, you know. Let me put it this way: in the first couple of weeks they are no help, even if they have worked for us before. After that they start to produce, but I guess they never turn out more than 75 per cent of the rate we get from the regulars. You know, you put your finger on a real problem because I'll tell you—it's getting worse each year. When we started here, we didn't have much trouble getting people for temporary work, but a lot of new industry has moved in around here. We just don't have the same labor surplus to draw on. These days we take anybody we can get, and it's mostly women. The other problem is that the job is getting more complicated, especially with the new plastic materials we are using. You can't teach just anybody to use the new seam-welder in a few days. We had a lot of waste this year!

Mr. Lewis: That seems to substantiate my suspicions, Dave. Now, let's see if we can estimate what this is costing you.

According to your payroll records, the direct labor in the past year came to about 61,000 man-hours. Of this, 32,000 man-hours was attributable to the regular workers and the remaining 29,000 was work done by temporaries. If we use Dave's estimate and say that these temporaries are about 75 per cent efficient compared with the regular workers after the first couple of weeks and call it, say, 50 per cent in the first two weeks, we get . . . hmm . . . it looks as if you are paying for about 8,000 to 9,000 more man-hours than you would if you had all regular labor—and at $2.50 per hour, that is about $20,000.

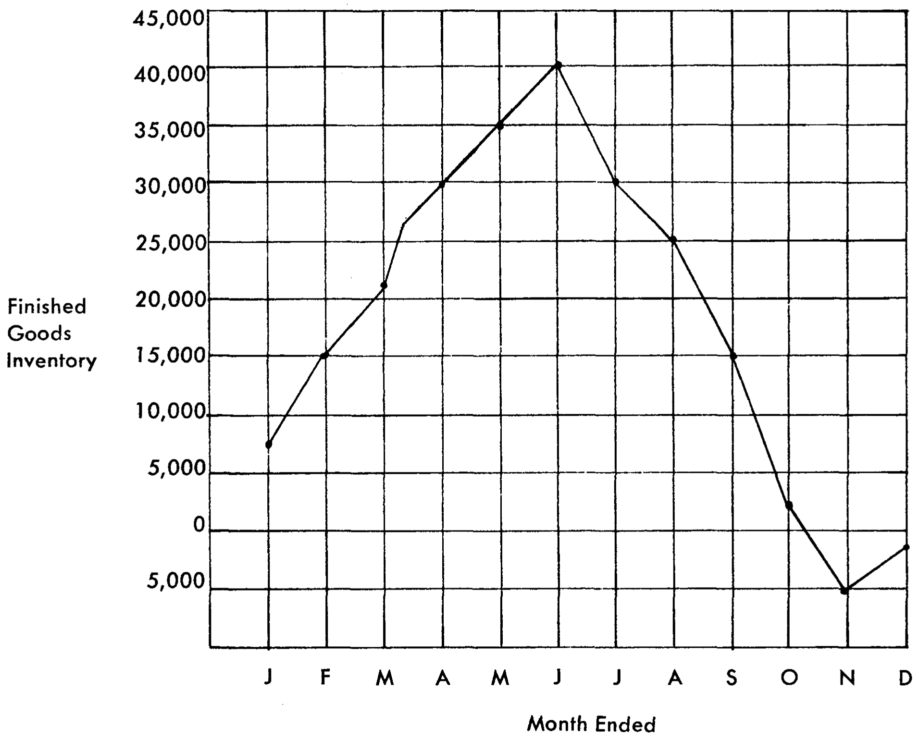
Mr. Castaldi: And that doesn't include the cost of the materials they waste—or the time my foreman spends training them.

Mr. Topley: As much as that? I guess we never have tried to figure out what the temporaries were costing us. But what about the other side of the picture?

Mr. Lewis: Well, if you build up inventory, you have to store it, and that ties up funds. Let's set a flat rate of production at 15,000 units a month. That figure is based on the assumption that total sales next year will be about the same as this year—180,000 units. I have drawn up a graph (Exhibit 2, page 32) which shows what your inventory levels would be at various points in a full cycle of twelve months, starting with a nominal balance of, say, 2,000 units after the Christmas sales, assuming that the pattern of demand is pretty much the same as last year.

You can see that finished-goods inventory rises to a maximum of less than 40,000 units and begins to decrease by July. In fact, it reaches a negative balance in November and December. This indicates that a moderate amount of overtime would be required at that time or else you will have a backlog order situation for a few weeks. The average finished-goods inventory, taken over the whole year, would be approximately 20,000 units, and it is on this figure that we need to calculate inventory carrying costs. The direct cost per unit—the actual out-of-pocket expense to the company—is $1.30,

Exhibit 2



and on that basis you will be tying up $26,000 in extra working capital. This would probably mean that some additional cash would have to be obtained, but, in view of this year's sales figures and the economies that would be realized, I don't think there would be any difficulty in getting the bank to provide a term loan to finance this, especially since it perhaps could automatically be liquidated during the peak sales season."

Mr. Topley: We may ask you to talk to the bank for us if we decide to go ahead with this, but I don't anticipate any trouble there.

Mr. Lewis: Of course—I'd be glad to do that.

Now, there is no question that the use of funds to finance increased working capital will force you to forego other opportunities. Therefore, no opportunity costs are involved. So, the cost of these funds will be the rate of interest you would have to pay for them; perhaps 6 per cent—which would be $1,560 per year.

What other costs should be considered? What danger is there that some of the inventory items would be obsolete before they were sold? And what about storage space—do you have room for a maximum of 40,000 units in the plant or does it mean that you would have to rent storage space?

Mr. Topley: Very little danger of obsolescence—these are good standard lines. We add a new one from time to time, but rarely drop one. These are not really fashion items. But storage space would be a problem. What do you think, Dave?

Mr. Castaldi: I don't think it would be difficult to find room to store the products, though we will have to build a lockable cage for security. We could take some of the space now used to stockpile raw materials before the busy season. If we are going to have that amount of inventory, though, I'd want to have a full-time storeman and I guess we should take his wages into consideration.

Mr. Topley: I agree with that. Well, John, you have given us something to think about. I need time to think about it and check on a few of these figures. You have opened up a range of possibilities: We could go halfway towards your scheme, for instance, and spread our production to some extent without removing the cyclical effect altogether. Let's discuss it again in a few days.

Results

Basing his decision on the estimates in Exhibit 3, page 34, Topley decided to institute the policy suggested by his CPA.

Topworth Toy Company's management decided to tell their CPA that they had enough information under the circumstances to proceed with implementing an inventory control system. As Mr. Topley put it, "John, I see I should have taken your advice more seriously on past recommendations. What we plan to do now is go ahead on our own; however, if we run into any snags, I expect to call upon you to help us. It's not that I don't want to pay your bills—for I fully expect you

Exhibit 3

Economies offered by suggested level-production plan	
Savings in direct labor	$20,000
Reduced scrap and offcuts	4,000
	$24,000

Additional costs associated with proposed scheme	
Interest charge on additional working capital	$ 1,600
Cost of storage space	nil
Storeman's salary	5,000
Provision for pilfering and spoilage (estimated)	800
	$ 7,400
Estimated net saving per annum	$16,600

to charge me for your time on the matter—it's just that I think we should go over some of your past recommendations and see whether we can use your services in another area first."

The proposed change was later put into effect. The "level" production volume of 15,000 units per month was maintained by a regular direct-labor force of 28 men, which was within the plant's single-shift capacity. Management estimated that some overtime would be required later in the year, but that the overtime payments would be more than covered by the savings of the extra shift bonus payments.

The change-over to the new system raised other problems for the company. Production was no longer determined by orders received; therefore, the question of how much should be produced and economical production run sizes has become important. The batch-size problem was met through the use of an "economic lot size formula." Lewis is currently working with Mr. Castaldi to introduce a formula into the company's operations. A second problem—that of deciding what the total annual production volume should be—is and will remain an important factor in the company's planning. Instead of waiting for orders, Topley is constantly anticipating changes in total demand and making allowances for any long-term trends which develop, to avoid being trapped into changing the production level on the basis of short-term fluctuations in demand.

Management's job has become more complex and demanding in the

Topworth Company, but Topley is convinced that the financial rewards will more than compensate for the extra care required. Lewis was engaged to establish a cost accounting system which he was also asked to implement. It is probably no exaggeration to say that the change in inventory policy has introduced a new phase in this company's corporate development.

The National Ventifan Company

In April 1968, George King, production control manager in The National Ventifan Company, was considering a problem that had arisen within his area of responsibility. On a number of occasions in recent months, important orders had been delayed because parts were not available. The most serious incident had taken place a week ago. A valuable order for dust extraction fans for a newly constructed chocolate candy plant had been delayed beyond the date set for contract completion because a necessary ball-race bearing was out of stock. National Ventifan executives believed that an important customer had been lost because of this incident and the company president, Alan Barber, had made it clear to King that no further shortages of this kind were to occur.

Background

National Ventifan was a medium-sized manufacturer of fans, blowers and general air-moving and dust-extraction equipment situated in the Great Lakes region. The company was founded in the early 1920's and had, from its earliest years, found its major market in the regional food-producing industries, particularly flour mills, chocolate producers, bakeries and breweries. Sales growth had been rapid in the early 1950's but had become progressively slower in the past decade. Sales revenues for the financial year ended December 31, 1967 had been $16,500,000, an increase of 2 per cent over the previous year and 5 per cent lower than the company's "best-ever" year of 1966.

The company's products covered a wide range of air-moving capacities and range from fairly small standard lines of ventilating fans for warehouse use to large special-purpose dust-extraction "cyclone" units built according to a customer's particular requirements. All models, however, consist of the same basic components, electric motors and associated electrical items such as: speed controls, fans and impellers of varying degrees of complexity, spindles, drive shafts and bearings, and sheet-metal castings and ducting.

National Ventifan's plant facilities included a forge and an extensive pressing and sheet-metal working capacity. Most of the parts, however, were purchased from outside vendors. Purchased parts included all motors and electrical equipment, bearings and such "standard" items as screws, nuts, lock washers and bushings. The company had a policy of offering servicing facilities and spare parts for all models of current or recent production. Recent production was generally interpreted to mean ten to fifteen years after the point of sale.

While this was the general interpretation, the company did maintain spare parts for large volume products even though some of them had been out of production for more than fifteen years. Management believed that their spare parts and service policy played an important part in building customer loyalty and regarded the provision of these facilities as a basic company strategy.

In 1967, the company maintained inventories of more than 9,800 separate items. Of these, 6,500 were used in current production models, almost half of which were also used in noncurrent models. Another 2,000 items were held for use only on non-current models, and the remaining 1,300 items were classed as maintenance items or consumable stores.

Perpetual inventory records were maintained in a series of ring binders within which record cards could be inserted or removed as desired. A separate record card was maintained for every item and, at least in theory, they showed the number of items available and on order at any given moment. All receipts and issues of the items were recorded and a running total maintained. Similarly, orders placed were recorded and the running "orders outstanding" was reduced by the amount of new stock actually received. In addition to these running totals of items on order and in stock, the record card carried a listing of the supplier(s) from whom the item was available and a recommended order batch size. This order quantity was established when a part was ordered for the first time and was rarely, if ever, revised. (A specimen inventory record card is reproduced as Exhibit 1, page 38.)

The company's inventory-control staff consisted of the head storekeeper, three storekeepers, and a clerical staff of six employees designated as store clerks. Production or maintenance workers requiring items from the storeroom made out requisition slips detailing the item (by serial number), the quantity needed and the requesting department. The requisition slips were collected by the storekeepers and forwarded twice daily to the stores office where they were used by the clerks to update record cards. Whenever a stores clerk, in recording an issue, noticed that the level of remaining stock of that item appeared to be "dangerously" low in relation to recent usage of the item (as recorded on the card), he would call this to the attention of the head storekeeper. The head storekeeper would then look into the situation, taking into account outstanding orders for the item which had not yet been received from the supplier, and would decide whether or not a further order should be placed.

Exhibit 1

STOCK RECORD CARD			F. 207			
VENDOR (S): A B C Mfg.			USED IN: Current Production ☒ Spares and Service ☐ Plant Maintenance ☐			
ORDER QUANTITY: 250						
ORDERS PLACED			RECEIPTS AND ISSUES			
VENDOR and ORDER NO.	QTY.	DATE	QTY.	DATE	BAL.	IDENTIFICATION
A B C 1066	250	7/28/65	250	9/3/65	250	Recd. A B C—1066
A B C 1215	250	1/12/66	170	9/12/65	80	Dept. 3—2107
			50	1/10/66	30	Dept. 1—3059

King Considers the Problem

Mr. King was well aware that the system currently being used by the company was open to serious criticism. He had devoted considerable time to inquiring into the causes of recent "out of stock" situations and had decided that two very important problems existed. In some cases a clerk or the head storekeeper had made an error of judgment and the order for replacement items had not been placed in time. In other cases, particularly where production of a particular model was increasing rapidly, the replacement order had been placed when indicated but the amount requisitioned had been too small. Therefore, the stock was virtually exhausted before the items were delivered. Even where a further order had immediately been placed, a stock-out had occurred before the second batch had been received. King also felt that even where there were no incidents of a stock-out, unnecessary clerical work in the stores office was contributing to the total inefficiency because many small orders for the same item were placed within a short period of time. He realized, in short, that firm decision rules were required in order to answer the questions of when to place an order and how much should be ordered at any one time.

Attempting to find a solution to these problems, King read a number of articles on inventory control problems and was aware of the existence of a number of formulas and "decision rules" which might be of use to him. He wasn't sure, however, whether or not it would be possible to implement such procedures with his present staff, and without completely disrupting the stores activity.

Questions

1. What techniques do you think may be useful to Mr. King in solving the problem?

2. How can the magnitude of the clerical task be reduced?

3. What difficulties are likely to be encountered in *implementing* your solution and how would you surmount them?

King Receives Some Advice

One day late in April, King lunched with the company's president, Alan Barber, and the conversation turned to the problem of making certain that an adequate supply of production parts was available. King told Barber that he was considering the introduction of new inventory control decision rules, and of his uncertainty about the difficulties likely to arise in implementing the changeover. Barber agreed that a real problem existed and made a suggestion. He said that the company's independent auditors, a long-established local CPA firm, had an established management services department offering general consulting services to their clients. Perhaps they can be called upon to lead us out of our stock-out problems, Barber suggested. "It might be worth getting in touch with them and seeing what they are able to suggest."

A few days later, Barber and King met with the head of the accounting firm's management services department, Harry Smiley. Mr. Smiley had worked with the firm for a few years after qualifying as a CPA and had then been given leave to attend a two-year M.B.A. program at a graduate school of business. He had been given the job of setting up the management services activity on his return from the program in mid-1964 and now had two assistants, one of whom accompanied him to the meeting.

King opened the meeting by describing the problems the company had encountered—and stating his own position. The following discussion ensued:

Mr. King: I know that there is a rational approach to these problems. I realize that we are wrong in using reorder quantities established years ago and probably never revised, even though our annual usage now might be much higher than it was when the quantity was established. I am aware that we can use a formula that will tell us how large our order quantities should be, on the basis of our ordering costs and annual usage, and that we should recalculate the quantity every time we have a significant change in usage levels. I know that we should establish reorder points for each item on the basis of the supplier's lead time. But the size of the job is terrific.

Look, we have over 9,000 different items. That means working out 9,000 economic order quantities. That's a huge task, even if it is a fairly simple calculation. Then, even when we have the quantities established, we have to continually review our usage. Seems as if I'll need twice as many store clerks to keep up with all this.

Mr. Smiley: Well, it would be a big job to apply that sort of system to every item of inventory, but you may not have to. The first thing that should be decided is how many items *need* to be kept under a tight control.

Mr. King: You mean that we should apply the system only to current production parts and not to service or maintenance parts? I've thought of that possibility but it still leaves over 6,000 items and that is still a big job.

Mr. Smiley: No, that isn't what I had in mind. You should start by finding out what items really figure significantly in your operations. The cost of some items may be very nominal, and even if usage on those items is high, you may be able to play safe by keeping a large inventory without tying up cash. Other items may be of a high value but are not used very often. The critical items are those that are both fairly expensive and have heavy usage. Now if it is possible to multiply usage by the cost per item, a usage value figure for every part can be developed. Then the usage-value figures can be used to classify the parts as a basis for inventory control methods.

Mr. King: That seems to make sense. To what extent would it simplify our problems? Can these classifications be set to determine how many items we should control closely, or what?

Mr. Smiley: The classifications you use are entirely up to you. I would expect to find, though, that about 10 per cent of the parts account for at least 75 per cent of the total usage value, and these are the ones you should exercise close control over and revise frequently. Those items we commonly call class "A" items. Then, if you agree, we could divide the remainder into two categories. For the "B" items you would use the same decision rules as the "A" items but with a less frequent review of usage rates and less frequent revision of order quantities. For the "C" items you might do away with stock records altogether and use a physical control system.

Mr. Barber: You mean the old two-bin method?

Mr. Smiley: Right. The two-bin method can save you a lot of clerical work as long as you don't apply it to everything. You reduce the number of items for which economic order quantities have to be calculated, thereby reducing the number of items requiring close continuous control. You will still have to calculate reorder points for all items on the basis of lead time. But the running total records are eliminated altogether on some items, which results in a considerable saving of clerical routine.

Mr. Barber: Where do we go from here? Can you help us?

Mr. Smiley: Certainly, we can help. I would suggest that my assistant, Bob, spend some time with your stores people explaining the idea of usage value to them. We'll want a usage value figure for every item. I'd appreciate it if you could introduce Bob to them, and make sure they realize that he is trying to help them and is not about to put them out of a job. Also, you could have your people start collecting the other information we need. We'll want an annual usage figure for every part but that is readily available from the record cards. We will need to know the lead time for each part. We will also have to determine how much it costs to hold inventory, including both the warehousing and cost of the funds tied up in inventory. Bob will keep me informed of progress and we'll get together again when we have the figures available.

Al, it would also be a good idea to free up George, or his assistant, to work with Bob on this study. You will then be able to carry on with the system once it is in operation.

I will verify our discussions with an engagement letter as soon as I get back to the office. Roughly the job should take us about four months requiring about 50 man-days by our staff. The cost will probably be in the neighborhood of $8,500 plus expenses.

Mr. Barber: Harry, if this does the job, it will be well worth the cost. I have a feeling that our stock-outs have already cost us at least three times that in customer relations. Let's get on this matter as soon as possible. I'll let our boys know that I'm backing this project 100 per cent and that I have assigned George and his assistant to work with you.

Making the Survey

During the next six weeks Smiley's assistant, Bob Scott, and Ventifan's stores-control staff completed a usage-value analysis of all items in the company's inventory. As a first step, Mr. Scott took a random sample of 1,000 inventory items and performed a usage-value analysis on the sampled items. This analysis provided a result that conformed fairly close to Mr. Smiley's prediction in that 10 per cent of the sample items accounted for 84 per cent of the total sampled usage value. A similar analysis was then performed on the entire inventory.

The calculation of the usage values was not a purely mechanical one. Considerable discretion was needed in deciding what figures to employ for the "annual usage" factor. In most instances, however, the record card indicated that usage during the past year had been abnormally high or low. It was decided that an average figure taken over the past three years should be used in those circumstances.

The completed usage-value analysis was tabulated on the basis of cumulative percentages of total inventory items and their respective cumulative percentages of total usage-value. This tabulation is reproduced as Exhibit 2, below.

Exhibit 2

Cumulative Percentage of Items	Number of Items	Cumulative Percentage of Total Usage-Value
10%	986	74%
20	1,972	82
30	2,958	88
40	3,944	94
50	4,930	96
60	5,916	97
70	6,902	98
80	7,888	99
90	8,874	100
100	9,860	——

It will be observed that 90 per cent of the total number of items accounted for 100 per cent of the total usage-value. This was attributed to the fact that some items were found to have had zero usage during the past three years, and, therefore, contributed nothing to the sum of usage values. In other words, virtually ten per cent of the items being carried in inventory were no longer used and had not been used for three years.

Establishing the cost of placing an order was another matter requiring considerable judgment. The Ventifan Company had never availed themselves of clerical time studies and had no predetermined time standards available.

Barber concurred that the cost of ordering should include the clerical task of originating an order form, and that some provision should also be made for the clerical content of the receiving and handling procedures that were involved. After some discussion, management decided that an amount of $10 adequately covered the various cost elements involved.

After considerable thought, management decided not to include any allowance for the cost of the storage space required to store the inventory. Mr. Barber argued that the company did not rent any storage space: all inventory was held in the in-plant storage facility, a building constructed twenty-five years ago. The revised inventory procedures were not expected to increase the absolute level of parts inventories and he hoped that the elimination of the "no-usage" items would in fact reduce the space required. He believed therefore, that there was no real "opportunity cost" or out-of-pocket expense involved, and that it would not be appropriate to include the cost per square foot of space used in the calculation.

On the question of the cost of funds used to finance inventories, it was decided to consult Mr. Barth, the controller. Smiley had explained to Barth that either the cost of borrowing funds, or an appropriate opportunity cost rate (in the form of the company's normal rate of return on funds employed), might be used, and that, while he himself favored the latter, there was no definite general agreement as to which method was the "correct" method. In Barth's opinion the significant factor in this case was the company's overall financial position. Management did not wish to increase their debt structure at the present time and was unwilling to approach their banking connections for loans in view of the past year's disappointing sales and profitability record. Mr. Barber had given explicit instructions that the inventory problem was to be solved without increasing the funds tied up in inventories. The approach consistent with this policy seemed to be the use of an opportunity cost rate, and suggested that the company's current rate of return on investment, 10.5 per cent, be used.

Designing and Implementing the New System

Early in August 1968, Barber and King met with Smiley and Bob Scott to decide what should be done on the basis of the information now available. They agreed that all items which had shown no usage during the past three years should be reviewed and, possibly, eliminated. It was understood that exceptions might have to be made for certain items: primarily spare parts for company machine-tools held in the maintenance department and the consumable stores storeroom. The majority of the more than 900 no-usage items were spares for long-obsolete company products. It was proposed that these items should no longer be made available from stock. In the unlikely event that further orders were received for such items, they would be specially ordered, since it was not reasonable for customers to expect all parts for such equipment to be available from stock.

It was readily agreed that the usage-value classification should be used as the basis for the new control system, but there was some discussion as to whether a two- or a three-category system was most appropriate. Barber finally decided that he would prefer to use a two-category system initially, and then possibly go to a three-category system later. He explained his decision thus:

"Harry, you said that there's no point in going to a three-category A-B-C system unless we are going to make a real difference between the way we treat the B and C items. I think that makes sense. I also think it might be a grave mistake to change too many things at once. The changeover to the order-quantity formula is a big step in itself, and it will be a while before we are familiar with it. We have to get use to the routine of reviewing the "A" item usage levels frequently, and we still have the problem of setting reorder levels for everything. I like the idea of doing away with the stock records for low usage-value items and using physical controls, but it would be a pretty radical step for us. Maybe we'll be ready to take that step about a year from now, but I'd like to wait until we are more familiar with the system."

The major task remaining was to establish reorder points for all items to be retained in inventory. The company's representatives on the project team were made to realize that the basic principle was to obtain a reliable estimate of the suppliers' lead time for each item and to set the reorder point at such a level that the stock on hand when the order was placed was adequate to satisfy normal usage requirements during this lead time. This task was time-consuming but the necessary information existed within the company. The stores foreman and his staff already had extensive experience with the time taken to obtain the most important items; additional verification was obtained by consulting the company's purchasing office or by comparing the dates upon which orders were placed and received as recorded on the inventory record cards.

The concept of safety stocks was more difficult to put across. King did know that it was good practice to build-in some additional stock as a safeguard against unusual demand during the lead-time period. However, he had no idea of how to determine the size of the buffer stock. Again, Mr. Smiley was able to clarify the problem. He stated:

"There is no clear rule on this, George. Buffer stocks are a way of buying protection against abnormal stock use. The more protection you want, the more you have to pay for it in the form of increased inventory with its associated holding costs. I can't tell you how much protection to buy; only you and your colleagues in the company can decide that.

"I would make two suggestions, though. First, you don't have to use the same degree of protection for all items. You might consider whether any particular group or class of items is more likely to result in holding up important contracts and use a greater degree of protection for those items than you would for all inventory in general. Second, in deciding where to set the level for any item, ask yourself 'what chance of running out of stock am I willing to accept: One chance in ten? in 20? in 100'? Then, if the answer is, say, 'one chance in 20', decide what level of demand during the lead time has one chance in 20 of actually happening and set your reserve stock and order point on this basis. A statistician would probably call this buying protection to a 95 per cent confidence level, but I think it is easier to understand it in my terms."

Results

Implementation of the first phase of the reorganization was completed by the end of August 1967. The policy committee approved the elimination of the zero-usage items, and 740 items were removed from inventory, leaving a total of 9,120 items.

That Mr. Barber was pleased with the results of the system can be determined from the concluding remarks that he made to colleagues at the local Chamber of Commerce meeting.

"We have placed our inventory control procedures on a rational basis, and I am much happier about the whole procedure. Moreover, we have been able to do this without any increase in the overall size of the inventories. We will not know the exact effect until we tally the inventory prior to our audit in a couple of months from now, but right now I would guess that the overall parts inventory has been reduced by about $70,000 and there are more savings to come. We have found that we were holding stock amounting to eight or nine years usage on some of the older items and we are slowly getting them down to reasonable levels.

"Best of all, we seem to have licked the stock-out problem. We did have a stock-out problem on one item awhile back on a line for which we had not yet established the safety stock and order quantity levels. Since then we haven't had a stock-out problem.

"There is still a great deal to do. I'm still not sure that all our safety stocks are correct; I guess we'll have to review them continuously. I am thinking of introducing a "C" category some time and using physical controls, but not immediately.

"All this has taken up quite a bit of my production control manager's time, but I think it has been worthwhile. We now have our purchased parts well under control. The next step is to apply this order-quantity formula idea to some of the parts we make in the plant, particularly the sheet-metal ducting where it is common to two or more models, and see what we can achieve there.

"Fellows, I think it was the best investment we have ever made."

Laminated Plastics Company

The management of Laminated Plastics Company was, in late 1966, engaged in a study to determine whether or not the company should purchase an electronic computer and what economies and advantages might be expected if such a step were to be taken. The possible applications being considered included payroll, sales order processing and customer records, and the control of materials and finished-goods inventories. This case, however, is primarily concerned with the inventory control aspects of that study.

The company had, in the earlier stages of its inquiry, considered machines produced by a number of computer manufacturers. Each had been invited to submit estimates of the equipment required and its approximate cost (or rental) on the basis of a general description of the nature and volume of the applications being considered. A single manufacturer had then been selected, on the basis both of the cost of equipment and of the considerable experience of comparable applications in other companies in the plastics industry. Laminated Plastics Company's staff and representatives of the manufacturer, General Automation, were, in September 1966, working together on an in-depth study of the operating efficiencies obtainable. On the basis of this study, Laminated Plastics would ultimately decide on whether or not to place a firm order for the data processing equipment.

Background

The Laminated Plastics Company was a medium-sized producer of a wide range of consumer and household plastic products and of plastic components for the electrical and automotive industries. Sales during the year ended June 31, 1966 amounted to $25,000,000. The corporation employed 1,200 people in three plants in the southern New England area.

The operations performed by the company included, typically, resin-mixing, impregnating, cutting, finishing and assembly operations. The company produced both finished consumer and household items, such as electrical fittings, and plastic components for the electrical and automotive industries. An example of a component produced for incorporation into products of other companies was the range of circuit-boards sold to manufacturers of radio equipment, portable tape recorders, and so forth. Approximately 60 per cent of the corporation's production was in final-use consumer items, and 40 per cent in "industrial" sales. The industrial production was predominantly in nonstandard components made to customers' designs, although a number of standard lines were offered. In 1966 the product range included more than 800 consumer items and 300 different standard industrial items. Approximately 500 different custom industrial items had been produced to order during the previous twelve months.

Inventory Control in Laminated Plastics

Responsibility for inventory control was vested in the three plant "production control" managers. Each production control manager was directly responsible to his plant manager and functionally responsible to the company production and operations planning manager, Barney Fisher. Procedures and decision rules to be used in setting and controlling inventory levels were determined by Mr. Fisher and his staff and standardized throughout the company although in practice the plant production control managers were allowed to use considerable discretion in the implementing of procedures.

A stores-control activity, consisting of a supervisor and ten to twelve clerks and storemen, was located in each plant. Each supervisor was responsible for both raw-materials inventories and for finished-goods inventories where appropriate. Management estimated that the stores-control staff spent approximately 35 per cent of their time in controlling raw materials and purchased parts used in the company's products and 65 per cent in controlling finished-goods inventory.

No company product was made in more than one of the three plants, and there were, therefore, no items common to two or more of the finished-goods stores. All plants did use similar raw materials. The raw material, and, to a lesser degree, purchased parts were stocked at all three plants. Some interplant transfer of components did take place.

For example, laminated pressings produced by one plant were sometimes used in a more complex product assembled elsewhere. The volume of such transfers, however, was small. The plants were not treated as separate profit centers.

Inventory records at each plant were kept on Kardex card files. The information maintained on the card for each item included a record of monthly total usage (raw material) or sales (finished goods), running total balance on hand, and a record of all issues and receipts of stock and orders placed. The information used in updating the cards was obtained from stores issues, from consignment notes and from receiving documents. Thus, at least in theory, the Kardex system provided an accurate and timely record of both the raw materials and components and the finished-goods inventories.

The standard inventory control procedures that were developed included the use of an economic lot size formula and a modified fixed-order-quantity reordering procedure. A definite reorder quantity or lot size which had been calculated for every item was recorded on a Kardex file card for that item, as was the reorder-point stock level. These reorder levels had been calculated on the basis of suppliers' or manufacturers' lead time and on the recorded consumption or sales of the item; a reserve stock element was included as protection against abnormally heavy demand during the reorder period. Whenever a stock clerk recorded an issue of raw materials or parts to production or a consignment of finished goods from stock, he entered the new running balance on the card and then compared it with the reorder level. If the balance on hand was equal to or lower than this level, a reordering procedure was initiated.

The clerks did not in all circumstances observe this set of decision rules, however. In many cases, a number of different materials were purchased from the same supplier, and transport and handling costs could be reduced considerably if some or all of these items were ordered at the same time. Similarly, in the case of company-produced items, setup costs could have been minimized by scheduling a number of related items together. To achieve these savings, a stores clerk who found that a particular item had fallen to its reorder point would examine the position of related items, i.e., items bought from the same source or produced on the same equipment. If any of these items were found to be "close" to their reorder points, they would be added to the order being placed. No definition of "close" was attempted: the clerk used his own judgment.

The company production and operations planning office had also developed and instituted a follow-up procedure on orders placed. All replenishment orders, whether for purchased parts and materials or for company-manufactured parts, were recorded in an order control file as well as on the Kardex record cards. One stores clerk in each plant was responsible for reviewing all orders shown to be outstanding on the order-control file at weekly or, where necessary, daily intervals. If warranted, the clerk carried out expediting procedures by telephoning vendors, in the case of purchased parts, and by using the production control department expediters in the case of company-made parts. The exact timing and degree of emphasis used in the expediting procedures were left to the discretion of the stores-control staff.

The company production and operations planning manager, Mr. Fisher, did not believe that the Laminated Plastics inventory control procedures were perfect. Emergencies did occur at times—usually because items which were shown on the stock cards as having adequate stock were found to have lower physical stocks. (Such incidents were ascribed to pilfering or to the stores control copy of the stock issue slip failing to reach the control office.) A further problem was the deterioration of raw materials in the store. Stock handlers were instructed to use a "first-in, first-out" procedure but did not always do so. On the whole, though, Fisher was well satisfied with the system in use, and doubted that any major improvement was possible.

Suggested Computer Applications

Heading the team of general automation staff members working with Laminated Plastics in the computer applications study was Miles Stevenson, a senior methods analyst. Stevenson was convinced that the computer could be used to perform most of the inventory-control functions currently undertaken by the stores control clerks. He had worked on sales-installation teams with other customers who had decided to use their computers for inventory control among other functions, and he saw nothing in Laminated Plastics' case which would prevent an equally successful installation.

He met with considerable opposition, however, from the plant production-control managers and stores-control supervisors who argued that their tasks were far from routine and mechanical in nature and could never be satisfactorily undertaken by a machine. Stevenson discussed the problem with Mr. Fisher, and found him willing to give any suggestions serious consideration. But, Fisher's basic attitude was one of skepticism, and Stevenson realized that he would be extremely difficult to convince. The following exchange summarizes their respective positions at this time:

Mr. Fisher: You'll have to produce some good arguments to make me go along with you on this, Miles. I think we have a good system working here; we have evolved it over a number of years and most of the "bugs" have been worked out of it. We have a good team who have learned their jobs the hard way and know how to handle most of the problems as they come up. We give them working rules for guidance, but they use a lot of common sense in interpreting them. As I understand it, to put the problem onto your machine you'll have to reduce it to a set of rules to be followed in prescribed circumstances. Those rules will have to cover every possible situation, because the computer can't use judgment. Well, I don't think it can be done.

Mr. Stevenson: I have been getting the same argument from your plant people, so let me see if I can answer it for you. You are right when you say that the machine will only work according to the rules we build into the program, but those rules can be pretty sophisticated. The question is, how much of the "discretionary" activity your people perform can be reduced to a set of rules (even though the rules may be much more complicated than simply "Order when stock on hand falls to 250" or something of the sort). On the basis of past experience, I'd say that most of it can. The other point to bear in mind is the information flow we can build into the system; we'll be able to give you an analysis of usage, outstanding orders or anything else you want simply by building in sub-routines to do this after the daily updating run.

Mr. Fisher: That sounds impressive but I don't believe that I need any more information than I get now. Our records are as comprehensive and up to date as we can make them, depending only on the accuracy of the documents we use to update them—and, remember, this is a limitation your computer is going to share. I can get any sales or consumption analysis I want from the cards, and we already have outstanding-order files. The cards are a flexible system, too—if we want to put additional information on them about a particular part or supplier, we can do so. No, I doubt if you could produce any useful analysis that I don't now get and you might turn out pages of stuff that I won't even read. Sorry, but I'm still not convinced.

Questions

1. Do you think that Laminated Plastics should transfer its inventory control to the computer? Why?

2. If you feel that further study is required, to what areas would you direct the study? Who should undertake it?

3. If you do not believe that the use of a computer is practicable in this company, can you suggest any way of improving the existing manual system?

Finalizing the System

Study of the potential uses of the computer in Laminated Plastics Company continued throughout 1966, and agreement on the specifications of the system was reached in February 1967.

During this period, Stevenson and his team had many more talks with Fisher and the production control staff. The final decision was that a mixed manual-automatic system of inventory control would be introduced. Fisher had withdrawn slightly from his previous position on the use of automatic inventory control; possibly, some pressure had been brought to bear on him by the president and other members of the senior management team. As the decision to purchase the computer had now been made, management was determined that the equipment would be fully utilized. Even more important, the company controller and his staff were convinced that major improvements in certain accounting functions might be achieved if the inventory control records could be combined with certain accounting and cost-control records to provide a unified order-financing and stock-control system. This view was supported by Robert Spencer, a partner in the established Connecticut CPA firm which serviced Laminated Plastics in an advisory capacity. The controller later described his motives for consulting Mr. Spencer as follows:

"By October of 1966, I was beginning to worry about the decision we were to make. I suppose every company considering a change of this magnitude has a similar problem. We knew our old system pretty well. We knew also that it could be improved in many areas, but the changes the General Automation people were suggesting seemed pretty radical. Well, I wanted a second opinion.

"I am not suggesting that the manufacturer's team would deliberately mislead us, but they are all computer enthusiasts—they have an emotional commitment to their machine. Also, they don't know our operations as well as we do and might discount things that look trivial but could become major problems. We have a lot of faith in this particular CPA firm: they are familiar with our operation and they keep up to date on management techniques. So we decided to call them in."

During the next few weeks, Spencer worked closely with the General Automation and Laminated Plastics teams and occasionally acted as mediator between the two, particularly in the area of inventory control. He knew that many of Fisher's reservations were justified and that certain inventory control functions would be performed less efficiently if transferred to the computer. But, being in a better position than Fisher to look at the overall needs of the company rather than those of a single functional area, he recognized the advantages of an integrated system of the kind suggested by Mr. Stevenson. As Fisher had considerable respect for Spencer's judgment, the development of the mixed-system inventory control proposals was greatly facilitated by that CPA's involvement.

It had been apparent since the beginning of the study that the order financing and accounts receivable systems being planned could be effectively operated only on a system giving random access to key file information, and the specifications of the equipment ordered included a disc-type random access storage unit. To obtain the full benefit of such a unit, the systems team argued that it would be necessary to maintain the finished-goods inventory on random access disc file. The final step after receipt of an order for stock products, for instance, would be to use the random-access facility to ensure that adequate stock was available. Under the existing manual system, this check was made by the order-processing clerk telephoning the appropriate stock-control clerk, who answered the query by reference to the card-file record. By including certain additional information with the finished-goods inventory records on the random-access unit, it would be possible to use the file in the preparation of a number of accounting reports. It was decided that selling price and standard cost would be included in each item's file record. By multiplying the quantity ordered by the stored selling price for each item, the value of an order could thus be automatically calculated and used for invoicing purposes. A subroutine could later be developed which would accumulate these order dollar values by salesman identification code to provide a basis for the evaluation and compensation of the sales staff. The total sales to date for any item could automatically be multiplied by its standard cost to give a running total cost of goods sold. Finally, it was decided that the file record for each item in finished goods should include its weight and cubic capacity, so that the total weight and volume of every order could automatically be calculated as a guide to its delivery routing.

In order to achieve these benefits it would, of course, be necessary to centralize the finished-goods stock records, which under the manual system were kept in three separate files in the three plants. But the control staff argued that they required frequent access to these records. The system team responded that the automatic checking of stock availability for orders received would eliminate most of the queries they were required to answer and that the file updating program would print out a daily list of stock items which had fallen to their reorder levels. The few remaining instances in which a store clerk required an immediate check on the inventory status of any item might be met by a visual inspection of the appropriate stores location—i.e., a physical check. An agreement was reached that there would be a trial period during which the old and new systems would be run in parallel. The master finished-goods file would be built up on the random access unit in the computer section at company headquarters, which was located at the largest plant. The Kardex finished-goods files would continue to be maintained in all three plants, however. Only when all parties were satisfied that the system was working satisfactorily and that the programs had been fully tested would the final changeover be made and the Kardex files discontinued. As a further safeguard against the loss of the finished-goods inventory record by machine malfunction, it was agreed that a "father and son" file processing technique would be used. This means that a copy of the entire file would be made each day before the updating run was started. In the event of a malfunction, it would then be possible to read back the file as it stood before updating and repeat the run.

One of the provisions of the mixed auto-manual system was that although the finished-goods records would be maintained by the computer the reordering decisions would not be automated. This had been arrived at after considerable discussion. Stevenson and his team had proposed routines which would perform some of the "discretionary" work of the clerks. Where a group of parts was purchased from a single vendor, and shipping economies might be achieved by ordering all at the same time, it was suggested that the part numbering system be modified to give all parts in the group a common suffix. When one such part reached its reorder level, the program would call into memory all other parts in the group. Each parts file record would include a "supplementary" or "secondary" reorder level, and orders would be placed for those parts which had fallen to these levels. Similarly, it was suggested that the follow-up function on outstanding orders might be automated by specifying an "emergency action" level (somewhat below the reorder level), and using a subroutine to print out a list of all parts which had fallen to "emergency" levels after each updating run. Fisher and the plant production control managers held that, at best, this system would only simulate the work of an inexperienced stores control clerk—that it would never be able to exert judgment and flexibility of which an experienced man was capable, and that it offered no advantages over the manual system. Spencer agreed with this view, and it was decided that the computer system should be confined to file updating and the printing out of a list of stocks that had reached reorder level with all further action being taken by stores clerks in a reorganized central finished-goods stock control office. The computer would also be used to print out the list of related items as described above, but the decision as to whether or not to order would be made by the clerks.

Both the General Automation team and Laminated Plastics believed that there would be little advantage in automating the raw-materials and production-parts stock records. Pressing reasons existed for retaining these records in the plants for use in production-scheduling activities. One of the few advantages of a centralized and automated system in this area would have been the ready valuation of raw-materials inventories; management considered this a trivial matter compared with the arguments against centralization. It was decided, therefore, that no change would be made in this area.

Considerable attention was given to the problems of material deterioration in storage and it was found that this was essentially a materials handling problem. The existing store layout made it very difficult in many cases to obtain access to the earliest dated batches of materials without first moving the more recent batches. This problem was answered by a revised stores layout giving two-sided access to all storage locations and increased storage in cage pallets.

Results and Conclusions

The implementation of the new inventory-control system was started in May 1967. By July the transferring of finished-goods records onto the computer was completed, though manual records continued to be maintained. These manual records were discontinued in January 1968. Raw-materials inventory records are still maintained on the manual system. Early in 1968 Mr. Fisher expressed his opinion on the performance of the new system in the following terms:

"We now have a fair degree of operating experience with the new system and I am reasonably satisfied with it. The system we did finally install was a common sense compromise. I hate to think what might have happened if we had gone along with some of the ideas the computer boys came up with in the early stages. They sure tried to remove the human element in our inventory control decisions. We now have the computer doing what it does best: routine updating of records and printing out of stock reports.

"I can't say that we have had any great benefits from the system in the pure inventory-control area. We certainly haven't been able to reduce our clerical costs, but we never really expected to. Both the General Automation people and Mr. Spencer emphasized that we should not expect to justify the computer in terms of labor savings. We do produce a number of reports and statistics faster than we ever have before, but that benefits the controller's area much more than it does mine. From my point of view I suppose the biggest benefit we got out of the whole operation was the shake-up. The pressure—I guess you could even say the threat—forced us to look at everything we do, why we do it, what rules we use and what the limitations of those rules are. This scrutiny produced quite a few side benefits. We found out what was going wrong with our FIFO inventory procedure, for instance.

"Obviously the results of the changeover have to be judged by the benefits to the company as a whole. In the inventory control area the gains were relatively small because we were already well organized. Ironically, though, we would have gotten more benefit from the shake-up if we had been less efficient in the past. The real benefit is the extent to which the finished-goods control function has been integrated with other company activities. We're now a step closer to the total integrated management control system that the management specialists keep talking about.

"One thing is certain: we don't have anything like an ultimate system. We are already thinking of taking another look at the raw-materials inventories and seeing if we can't make some use of all the sales analysis information we now produce to anticipate our raw-materials replenishment needs—now, that would be a radical change from anything we have done in the past."

Allen Appliances, Inc.

"This information is a complete surprise to us. We have always assumed that the pattern of retail sales was pretty close to the demand pattern as it reaches us from our distributors. This is the first time we have had any real data about retail sales, and it appears to be way out of line. I don't know yet what is going on here, but I am surely going to try to find out. I have a feeling that these figures may be the key to our production problems."

The speaker, Ray Miller, was the production control manager of Allen Appliances. He had been appointed to this position fifteen months previously after some years in the production planning activity of a heavy engineering company. Two months after his appointment, Miller had asked the marketing manager, David Hillstrom, to cooperate in a survey of the company's retail outlets. All retailers were asked to maintain a record of their dollar volume of sales of Allen products during each month of 1966. In January 1967, Miller had just received the last of these figures, and was in possession of a complete schedule of month-by-month retail sales for a whole year. No such survey had previously been undertaken by the company. The pattern of sales revealed in these figures was very different from the assumptions that Allen management had previously held about the sales of their products, and Miller was trying to understand the significance of the data now in front of him.

Background

Allen Appliance Company was a small manufacturer of household utensils, situated in an industrial area of northern New Jersey. The company's products were predominantly metal fabrications and included such items as can openers, aluminum pans, storage containers and wire-mesh sieves. Almost two hundred separate items were produced in the company's one plant.

Sales during the financial year ended December 31, 1967 were slightly more than $2,000,000, which was the highest dollar sales volume in the company's history and represented a 5.5 per cent increase over the previous year. Sales had increased in each of the previous four years at rates varying between 3 and 5 per cent per year. The pattern of sales was highly seasonal with a single peak in November and December of each year and a marked low in June and July.

Allen products were sold to ten independent distributors situated in the eastern and southeastern states. These distributors differed little in size, and sold the products of a number of other manufacturers, some of which were in direct competition with those of the Allen Company. They supplied approximately two hundred retail outlets. Most of the retail outlets were independent hardware stores. Each distributor maintained a small sales force that called upon the retail outlets approximately once every two weeks to solicit orders. These orders were filled from the distributors' inventories and delivered, usually by their vehicles, three to eight days after the retailer's order had been received. The distributors themselves ordered replacement stock from the Allen Company every four to six weeks.

The company, for many years, maintained a policy of offering delivery of all items from stock held in the company warehouse adjacent to the plant. In practice this was not always possible, and an order backlog usually existed during a seasonal demand peak. Whenever the stock of any inventory item in the finished-goods warehouse reached a low point, a requisition was sent to the production-control office. Not all items requested could be scheduled immediately, however, and the delay between the production request and the receipt of new stock in the plant warehouse varied from five to fifteen days depending upon conflicting requirements for the machinery used to produce the item. Delivery from the plant warehouse to a distributor, when an item was available from stock, required approximately four days.

The Allen Company employed a sales force of two men who visited distributors to inform them of new products, and sometimes accompanied the distribution salesmen on their calls to retailers. Very little was done to promote the product lines. Company calendars were delivered to distributors to give to their retail customers, and some point-of-sale display materials were produced. No media advertising was used, however, and management did not believe that any significant degree of brand awareness existed for the products in which the company specialized.

Miller's Problem

Prior to Mr. Miller's appointment, the production-control activity in Allen appliances had operated without formal decision rules. All production requests were made by senior stores clerks whose judgment of when an order should be placed and in what quantities was based upon experience and recent distributor demand. The clerks attempted to match the level of inventory to the current level of demand. Therefore, in periods immediately preceding a seasonal peak, the production requests exceeded the quantity required to replace units sold and subsequently increased the basic inventory. In a slack season however, production requests were less than the distributor demand, thereby reducing the inventory which had been accumulated. No formal procedures for the calculation of order quantities or safety stock levels had been developed.

The seasonal nature of demand for Allen's products, as exercised through the medium of distributor demand, resulted in a highly unstable level of production and employment. Additional staff was employed during the "busy" season from August to December and laid off during the slack season. Considerable overtime also resulted during the months of October and December.

Mr. Miller later related:

"I was unhappy from the first day that I took this job about the way the company was handling its inventory and production control, largely because they were far too dependent upon the judgment and experience of a few key people. I was also unhappy about the way the production level and employment fluctuated. Considerable time and money was spent trying to train people who would only be employed for a few months. This company had the reputation of being a 'hire and fire' firm which meant that the majority of the people who came to work here were the ones who couldn't get any other job—the bottom of the labor barrel. I wanted to establish some rational decision rules and to adopt an inventory policy which would let us reduce the seasonal fluctuations in production to some extent and spread our workload more evenly over the year.

"I am fairly conversant with the various inventory control techniques. I know how to calculate economic order quantities, how to plan a fixed order quantity system and that sort of thing. The problem is that one of the critical parameters in calculating batch sizes and reorder points is the annual usage. The demand for most of our products is so seasonal that it is hard to know what demand or usage figure to use. Sure, I could use an 'average' figure but the amount of variance is so great that I wonder if the figures we calculate would be at all meaningful. Further, because the fluctuation is so great any attempt to level out production over the year would obviously result in massive fluctuations in the finished-goods inventory.

"Well, I had been trying to work out a compromise solution. One idea was to recalculate the order quantity and safety stocks at different points in the year; say, use one set of parameters in the period leading up to our peak demand and a different set during the slack period. A further possibility was to smooth out production to some extent without trying to level it altogether. There are all kinds of possible combinations. I have also been trying to get a better idea of just what the pattern of our sales fluctuations looks like—obviously we have some kind of a long-term upward trend with a cycle acting around that trend.

"That's about as far as I got when this data came in."

Results of the Survey

The management of the Allen Company had assumed that the fluctuations in retail sales were similar to those in distributor demand. This seemed to be a reasonable assumption, since retail sales were the determinant of distributor demand. Again quoting Mr. Miller:

"Let me give you an idea of the extent of the fluctuations in demand as we experience it from the distributors. Take a look at these figures.

These are our total dollar sales, month by month, for the last full year (1966).

January	$226,000	July	$120,000
February	224,000	August	126,000
March	206,176	September	150,000
April	176,000	October	210,000
May	144,000	November	238,000
June	127,000	December	242,000

Total for year: $2,195,000

Average monthly demand: $183,000

I can best describe the degree of fluctuation in relation to average monthly sales. We range from a high of 32 per cent above the monthly average to a low of 34 per cent. And that is a pretty big fluctuation.

"Now look at these figures. These are the total monthly retail sales of Allen products in our two hundred outlets during the same period:

January	$178,000	July	$164,000
February	176,000	August	170,000
March	175,000	September	179,000
April	172,000	October	193,000
May	164,000	November	196,000
June	156,000	December	194,000

Total for year: $2,117,000

Average monthly sales: $176,000

"Two things immediately stand out. One is that total sales by retailers over the year were considerably lower than total replacement demands on the factory placed by distributors. But this is not really surprising: it simply means that we finished the year with quite a lot of goods in the pipeline and in distributors' and retailers' inventories. We know that their orders will now fall off as they use up this surplus and draw their inventories down again.

"The second point is the thing that has rocked me back on my heels. Contrary to all our assumptions, if these figures are to be believed, retail sales of our products fluctuate very much less than does demand on the factory warehouse. The high point of retail sales was only 11 per cent above the monthly average; the worst month was only 11 per cent below. We have been assuming that our demand from distributors is highly cyclical because retail sales are highly cyclical, and suddenly I find that the retail sales of Allen products are comparatively stable! I will have to do some thinking about that."

Questions

1. What is happening in this company? How do you account for the phenomena revealed in the survey data?

2. What further information would you like to have? How would you go about getting it.

Allen Associates Obtain Outside Advice

Mr. Miller realized that the information revealed by the sample was likely to have considerable significance for other areas within the company, particularly the sales and production functions. At his request a meeting of senior management was held under the chairmanship of the company president, William Holland, to decide what should be done. Miller suggested that this data was of basic importance to planning the company's operations and that management should ensure its most effective use. There was general agreement on this point. Mr. Holland then voiced the opinion that this was a situation in which the company could use outside assistance. Allen Associates enjoyed a good relationship with their CPA firm which conducted the company's annual audit. In the past, Allen Associates had engaged their CPAs, Hartfiel, Vogel and Faber Co. to assist them on other matters. Mr. Holland decided that Hartfiel, Vogel and Faber should be invited to discuss this problem and to see what help they might be able to provide.

Ernest Spell, a partner in the CPA firm's advisory team, met with Messrs. Holland and Miller early in the following week. Mr. Miller outlined the situation, showed Spell the data on retail sales, and, after some discussion, asked for his comments. Mr. Spell said:

"I appreciate your surprise at the relationship which is shown here, but I don't altogether share it. I have seen a number of studies with a similar pattern. Clearly the demand from your distributors which you experience at the factory warehouse must depend upon retail sales, but the influence of retail sales is being exercised through a sort of multiplication factor. I think the answer may be in the way the retailers decide how much inventory they want to hold. But you need much more information before you can come to any conclusions. In particular, I would like to know more about the pattern of retailers' orders to distributors. All this may take time, but you will have a much better idea of the dynamics underlying the demand for your products. Once that information is attained, a solution would become more apparent."

Holland and Miller accepted Spell's suggestion and asked him to work with them on the problem. Spell instructed one of his assistants to devote his time to Allen Appliances, and the collection of the additional data was started. The company's ten distributors were asked to provide the company with data on the orders they received from retailers throughout the year. In most cases, a total figure for orders received for the week or month was available but did not show the volume for Allen products separately. Most of the distributors were willing to allow a representative of the company to have access to their records. Subsequently, Spell's assistant gathered data from four of the larger distributors in different areas, and it was decided that the figures obtained from them could be taken as a workable approximation of the general pattern of retail ordering. Spell and his assistant also visited 25 of the company's 200 retail outlets to talk to the retailers about their reordering procedures, and obtained a good idea of the methods used. The consultants and Mr. Miller's staff spent two further weeks analyzing the data they had obtained. A meeting with Holland, Miller and the other department heads concerned was held on the following week.

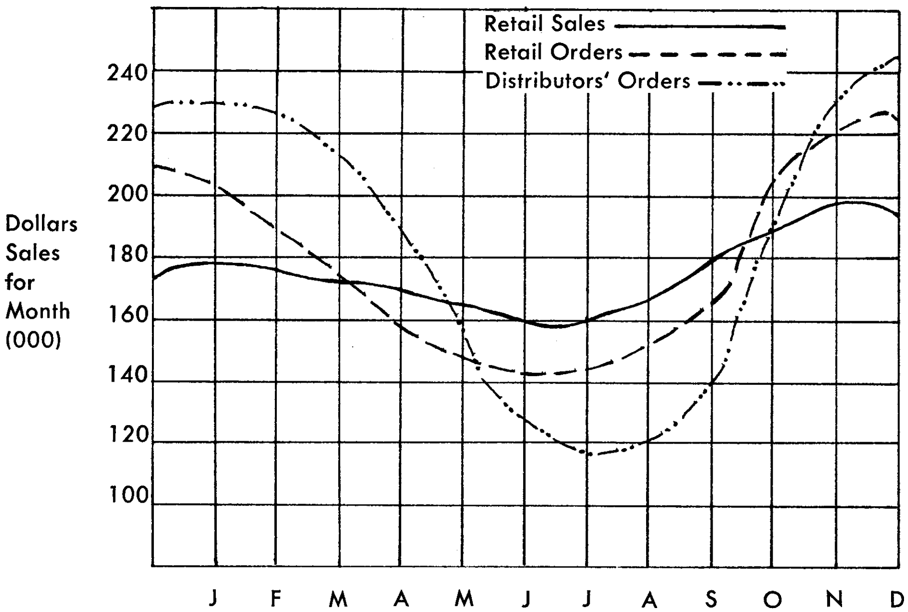
Spell Outlines His Findings

The results of the fact gathering activities and subsequent analysis may be summarized by the following extracts from Spell's presentation:

"We thought that it would be useful to get an idea of the pattern of retailers' orders, and we were right. The figures we have are an approximation, but we think they are representative of what actually happens. Now you can really start to see how this cyclical demand builds up.

"I would like you to look at this chart. (See Exhibit 1, page 66.)

Exhibit 1



On it we have plotted the behavior of retail sales, retailers' orders to distributors and distributors' orders to the factory for the year 1966. As the chart shows, we have also plotted the various monthly totals and then drawn smooth curves through them, as nearly as we could, to show the general pattern. These curves show an interesting relationship. Each level in the process shows a greater degree of cyclic fluctuations than the one preceding it: retailers' orders vary more than retail sales and distributors' orders to the factory vary more than retailers' orders. Each level reaches its peaks and vales a little later in time than the one preceding it.

"What is happening is this: there is a genuine cyclical pattern in the retail sales of Allen products, but not a very great one—certainly not as great as you have assumed it to be. This pattern is amplified twice, however: once by the retailers themselves, and once by the distributors. The result is that the demand you experience at the plant warehouse is very cyclical.

"Now, the question is, how does this amplification of the cyclical pattern arise? The answer seems to be in the way the retailers and distributors decide how much to order. We have spent quite some time looking into this. Take a typical retailer. He does not have any concept of economic order quantities. He uses a version of the fixed order cycle system, not the fixed order quantity system: he reorders when the distributor's representative calls—a fairly constant cycle of two weeks. He does have a decision rule, and his order is not simply a replacement order. He tries to relate his inventory position—more accurately, I suppose we should call it the safety stock element in his inventory—to demand, and he does this by making his inventory at the beginning of each period some multiple of current demand, as far as he can judge it. In practice, that means a multiple of actual demand experienced in the previous week.

"It isn't hard to see what happens. Suppose that a particular retailer has a policy of keeping inventory equal to eight times current weekly demand, and that in the past few weeks demand for Allen products in his shops has been around $200 a week. His inventory of Allen products will be approximately $1,600. Then, say, in the first week in September he sells $210 of your products. Halfway through the following week his distributor's representative calls to take his order. In the past few weeks he has been ordering $400 worth of stock: just enough to replace what he has sold in two weeks. This time, he will order replacement stock of $410, plus enough additional stock to bring his inventory to eight times his new demand level. This level will now be $1,680, an increase of $80. Thus an increase of $10 in retail sales has resulted a week or so later in the retailer's order to the distributor increasing by $90. There is your amplification! A few months later you go through the process in the opposite direction: the retailer's sales fall off and he finds himself with stock on hand equal to about twenty times the new demand level. So, he probably orders no new stock at all until he is back to his desired position with stock of around eight times current demand.

"Much the same sort of thing is apparently happening at the distributor level, and our inquiries suggest that their reordering rules are no more sophisticated than those of the retailers. So the magnitude of the change gets amplified again. And this time the amplification is even greater because the distributor orders less frequently and because the interval between placing an order and receiving stock is usually greater for him than for the retailer. He normally already has a number of orders outstanding with you—in the pipeline, you might say—and will probably increase his order even more to fill up that pipeline.

When demand falls off, you again go through the same process except in reverse."

Deciding Upon a Plan of Action

Following Mr. Spell's presentation, the group discussed what measures might be taken. As Mr. Miller later said:

"We knew that the big seasonal cyclic fluctuations were costing us money as well as giving us headaches, and we certainly didn't intend to go on living with it if we could do anything about it. Now that we know what is causing the cycle, or rather intensifying it, it should be possible to do something about it."

Based on Mr. Spell's findings, the management group decided that there were three basic ways in which they could seek to change the situation. These were:

1. Eliminate one of the levels in the ordering process. This would automatically eliminate the amplification effect associated with that level.
2. Try to modify the pattern of retail demand by means of marketing policies.
3. Persuade the retailers and distributors to modify their reorder policies.

The first possibility, eliminating one level in the system, could be achieved in either of two different ways. The Allen Company could decide to eliminate distributors and to supply retail outlets directly from the company warehouse. This would have required the creation of a much larger company sales force. Management felt that the relatively small volume of sales per retailer would make this uneconomical, and that the establishment and training of such a force would be a lengthy process. The second possibility was to establish a chain of company-owned retail outlets. This latter possibility was considered to be completely uneconomical and impossible to finance and was also rejected.

The second possible approach to try to smooth out the seasonal fluctuations by means of increased promotional efforts, advertising, increased distribution discounts, etc., during the off-peak period was given serious consideration but was ultimately rejected. The types of product made by the Allen Company were not items to which brand loyalty was usually attached and it was decided that advertising expenditure would not be rewarding. The possibility of offering increased margins to distributors at certain times was opposed by the sales department which considered it to be an undesirable policy to adopt, principally because it would be difficult to withdraw the extra discounts, when the peak demand period arrived, without causing resentment and allegations of bad faith.

The remaining possible line of approach appeared to be the most promising. Much of the amplification of the sales cycle arose because of retailer and distributor ordering procedures, and if those procedures could be modified it might be possible to minimize the amplification. This approach required little in the way of expenditures and was considered to be very diplomatic. The remaining question was what decision rule should they be asked to adopt. Mr. Miller said afterwards:

"We wanted to find a rational basis for the retailers' and distributors' inventory policies, and we were certain that we could eliminate the surging which had been taking place. We realized, though, that we must not try to sell them anything too static. Changes in demand do take place, both the seasonal cycle and a long-term upwards trend, and they must obviously be free to respond to these changes. The problem was to ensure that they did not respond too quickly. The established pattern of visits by distributors' representatives made it reasonable to assume that the retailers should continue to use a fixed order cycle system. Under this system there is an upper inventory level, and enough stock is ordered on each cycle to bring the inventory to this level. It was also reasonable to assume that this upper inventory level would be related in some way to sales and would change in response to changes in sales.

"We decided that what we required was a way of damping the response to these changes: spreading them over a reasonable period of time instead of putting them into effect all at once. We therefore asked the retailers to use their previous decision rules and to continue using their own ideas concerning what multiple of current sales their inventories should be. However, we requested that whenever a change in inventory level was indicated that the change be spread over the next four reorder periods instead of just one. The adjustment would thus be spread over two months. What happens then, is this: say that a retailer's sales have recently been steady at $200 a week and then increase to $210, and say that he works on an inventory of eight times weekly sales. The sales increase indicates an increase in total inventory of $80, but this is spread over four reorder periods. Therefore at the next reorder time, this retailer's order will be replacement demand of $410 plus $20 of new inventory, a total of $430 (see page 67). Under the old system it would have been $490, as you can see from this chart (Exhibit 2, page 71).

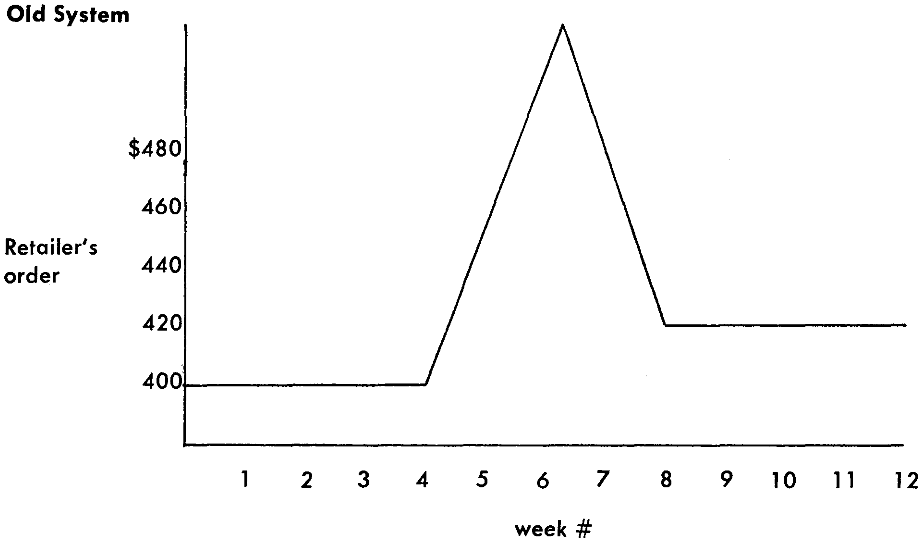
"The system we have introduced at the distribution level is very similar. I suppose you could argue that there is less reason to use a fixed order cycle system in this case and that we could have explored the use of a fixed order quantity system with them, but we didn't do that. The fixed order cycle approach works well because we supply them with a whole range of different items, and if we receive orders for all the items at the same time we can average deliveries at the lowest possible cost. An even more important consideration, though, was that we believed that our best chance of getting the cooperation of the distributor was to change things as little as possible. The 'damping' idea we introduced wasn't too great a departure from what they were already doing and we didn't have too much trouble getting them to go along with us.

"The changes we have made seem successful. We do not yet have the full 1967 figures available to us, but we do know that sales fell off much more slowly during June and July than they have in previous years. The lowest monthly sales figure came in August this year, not July, and was $136,000, compared with our 1966 low of $120,000. And the indications seem to be that the damping is working equally well in the current peak sales period. I can now start concentrating upon the implications of all this for our own plant inventory and production policies, and I intend to make use of Mr. Spell's services again in this area."

Exhibit 2

Retailer's Response to Sales Increase from $200 to $210 Per Week Occurring in Week 5

Old System



New System

Using "Damping"